Atlantic City Public Schools

Science

Grades 9-12

Curriculum Guide

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Science Department Faculty

Mrs. Diana Arndt	Teacher of Secondary Earth & Space Science (2017)
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Mrs. Mia Campo	Teacher of Special Education (Students with Disabilities)(Secondary (2007)
Mr. Mark Chando	Teacher of Secondary Biological Science (2004) Elementary Teacher of Secondary Science (1992)
Mr. Bjorn Christiano	Teacher of Secondary Biological Science (2007)
Mr. Kevin Corcoran	Teacher of Secondary Biological Science (2001)
Ms. Riana Cordoba	Teacher of Special Education (Students with Disabilities)(Secondary) (2016) / Special Ed Teacher of Secondary Biological Science (2015)
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Mrs. Courtney Keim	Teacher of Secondary Physical Science (2006)
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Mr. Frank Manzo	Teacher of Secondary Biological Science (1992)
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SCIENCE CURRICULUM
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Section I.

Introduction to the Guide

Scientifically literate individuals possess the knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity. The science standards are designed to help realize a vision for education in the sciences, engineering and STEM in which students, over multiple years of school, actively engage in scientific and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields. The learning experiences provided for students should engage them with fundamental questions about the world and with how scientists have investigated and found answers to those questions. Throughout grades 9-12, students should have the opportunity to carry out scientific investigations and engineering design projects related to the disciplinary core ideas.

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Section II

Philosophy

Science, technology, engineering, and mathematics (STEM) influence and permeate every aspect of modern life. Some knowledge of science and engineering is required to engage with the major public policy issues of today as well as to make informed everyday decisions, such as selecting among alternative medical treatments or determining how to manage important services like waste treatment, our water supply or understanding nutrition,, be able to understand the concepts of Climate Change, how to react to natural disasters and how things work to better preform everyday functions in our lives. In addition, understanding science and the extraordinary insights it has produced can be meaningful and relevant on a personal level, opening new worlds to explore and offering lifelong opportunities for enriching people's lives. In these contexts, learning science is important for everyone, even those who eventually choose careers in fields other than science or engineering.

Vision

The Atlantic City District recognizes the urgency to provide resources to improve instruction through exemplary and diverse practices which are monitored and analyzed through student achievement data. The District has the expectation that all students will achieve the Common Core State Standards at all grade levels.

Mission Statement

In order to meet the needs of all students, the District is committed to increasing student learning and improving teaching in the core academic subjects by using instructional strategies aligned with the Common Core State Standards and based on Scientifically Based Research. Parents will be active partners and key stakeholders with the Atlantic City School District to support their student’s intellectual, emotional, physical and social growth.

Standards

Atlantic City Board of Education has adopted both the New Jersey Core Curriculum Content Standards for Science which were adopted July 2002 and has directed the Science Department Curriculum Task Force to re-draft Each science Curriculum document to now include the Next Generation of Science Standards (NGSS)
Each of the Course Curriculum Documents included here will eventually be updated. Environmental Science, Earth Science, Marine Science and Chemistry Academic were completed in the Summer of 2018.

Standards can be found contained in each Course Curriculum document in the instructional planning.

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Section III

Graduation Requirements

Revision of the state minimal graduation requirements is one component of New Jersey's ongoing commitment to make its high schools more relevant to the 21st century and more effective in educating students. The updated requirements coincide with the revision of the state's nine Core Curriculum Content Standards (CCCS), which outline what students should know and be able to do at all grade levels, as well as the alignment of statewide and local assessments with the new graduation expectations and the revised CCCS.

The proposed graduation requirements include:

- **Language Arts Literacy --** 20 credits aligned to grade 9 to 12 standards
- **Math --** 15 credits including algebra I content (effective with the 2008-2009 9th grade class), geometry content (effective with the 2010-2011 9th grade class), and a third year of math that builds upon algebra I and geometry and prepares students for college and 21st century careers (effective with the 2012-2013 9th grade class)
- **Science --** 15 credits including laboratory biology (effective with the 2008-2009 9th grade class); chemistry, environmental science or physics (effective with the 2010-2011 9th grade class); and additional lab/inquiry-based science (effective with the 2012-2013 9th grade class)
- **Social Studies --** 15 credits including histories and integrated civics, economics, geography, and global content
- **Economics --** 2.5 credits in financial, economic, business and entrepreneurial literacy (effective with the 2010-2011 9th grade class)

The updated graduation requirements also include the introduction of the Alternative High School Assessment to replace the Special Review Assessment (SRA), which currently is administered to students who cannot demonstrate proficiency of current curriculum standards via the 11th grade statewide assessment. The proposal also includes a phase-in of personalized student learning plans to follow students from middle school through high school graduation. The personalized plans would set learning goals for students based on their personal, academic and career interests, and would include the involvement of teachers, counselors and parents. The graduation requirements are based on recommendations from the New Jersey High School Redesign Steering Committee and the department's Secondary Transformation Committee.

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Interdisciplinary Connections

Interdisciplinary instruction encourages connections among disciplines to help learners construct stronger knowledge schema. Because students could approach the content from different angles based on their interests, involvement, and background knowledge, there were greater opportunities to learn. Linking science and reading, writing, social studies, and mathematics through common themes or topics creates the potential for more effective learning.

Interdisciplinary instruction encourages meaningfully connections to integrated science, literacy, and mathematics in three ways: 1) by emphasizing process skills across subject areas, 2) by valuing inquiry as a common tool for learning, and 3) by employing a learning cycle model of instruction in all disciplines.

Teachers can start the process of designing interdisciplinary units by examining the standards in different curricular areas and finding commonalities. One place to start is with the *National Science Education Standards* unifying themes. The unifying themes (e.g., systems, change, models), as well as connected tools (e.g., measurement, representations), and shared processes (e.g., observing, predicting) are places for making meaningful curricular connections across disciplines.

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Modifications and Accommodations

Atlantic City high School **Science Department** **Modifications and Accommodations** **The following outlines the ways in which teachers can make modifications and accommodations for Students who are working on, below, and above grade level.**				
504 Plans	**Special Education**	**At-Risk**	**Gifted - Science**	**English Language Learners**
Specific modifications and accommodations for students with 504 plans will also be provided according to the students' 504 plans. Collaborate with after-school programs or clubs to extend learning opportunities. Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal	*Specific modifications and accommodations for special education students will also be provided according to the students' IEP.* Collaborate with after-school programs or clubs to extend learning opportunities. Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles and biographies). Provide multiple grouping opportunities for students to share	The possible list of modifications and/or accommodations identified for Special Education students can be utilized for At- Risk students as well. Teachers should utilize ongoing methods to provide instruction, assess student needs, and utilize modifications specific to the needs of individual students. Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). Use project-based learning Structure the learning around	Exposure to significant and deep content (advanced, accelerated, or compacted content) Abstract and advanced higher-level thinking Allowance for individual student interests Assignments geared to development in areas of affect, creativity, cognition, and research skills Complex, in-depth assignments Diverse enrichment that broadens learning Activities promoting cultural diversity Interdisciplinary and problem-based assignments with planned scope and sequence Emphasis on understanding concepts rather than memorizing facts. An inquiry approach with student opportunities as active investigators Opportunities for interdisciplinary connections Investigating real problems and situations Guiding students towards adopting scientific habits of mind	Provide ELL students with multiple literacy strategies. Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). Use project-based learning Structure the learning around explaining or solving a social or community-based issue. Allow extended time for assignment completion. Students can utilize technology such as text to speech software or Google drive to complete assignments Allow time for peer consultation/editing Restructure lesson using UDL principles (http://www.cast.org/our-

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articles, and biographies). Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). Use project-based learning Structure the learning around explaining or solving a social or community-based issue. Restructure lesson using UDL principles (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA). Allow extended time for assignment completion Preferential seating	their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). Use project-based learning Structure the learning around explaining or solving a social or community-based issue. Restructure lesson using UDL principles (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA). Allow extended time for assignment completion.	explaining or solving a social or community-based issue. Restructure lesson using UDL principles (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA). Allow extended time for assignment completion.	Ethics of science (e.g. solutions to world hunger and famine) Mainstream media reports about medical research An available forum for students to describe and discuss independent research projects Create a product for publication (Provide articles, technical reports, letters, or drawings based on the findings from their inquiry reports) Internship, mentorship, and other forms of apprenticeship by professionals in their field of interest.	work/about-udl.html#.VXmoXcfD_UA). **Bilingual/ESL Curriculum Handbook for Integrated ESL/ELA/Sci/SS** **Supporting ELL During Content Instruction** **Modifications for ELLs** **Accommodations for ELLs**

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Integration of 21st Century Life Skills and Technology	
Technology Content Standards	**21st Century Life and Careers**
8.1 Educational Technology: All students will use digital tools to assess, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge. **A. Technology Operations and Concepts:** **8.1.2.A.1** Identify the basic features of a digital device and explain its purpose. **8.1.2.A.2** Create a document using a word processing application. **8.1.2.A.3** Compare the common uses of at least two different digital applications and identify the advantages and disadvantages of each. **8.1.2.A.4** Demonstrate developmentally appropriate navigation skills in virtual Environments (i.e. games, museums) **8.1.2.A.5** Enter information into a spreadsheet and sort the information. **8.1.2.A.6** Identify the structure and components of a database. **8.1.2.A.7** Enter information into a database or spreadsheet and filter the information. **B. Creativity and Innovation** **8.1.2.B.1** Illustrate and communicate original ideas and stories using multiple digital tools and resources. **C. Communication and Collaboration:** **8.1.2.C.1** Engage in a variety of developmentally appropriate learning activities with students in other classes, schools, or countries using various media formats such as online collaborative tools, and social media. **D. Digital Citizenship** **8.1.2.D.1** Develop an understanding of ownership of print and non-print information. **E: Research and Information Fluency:** **8.1.2.E.1** Use digital tools and online resources to explore a problem or issue. **F. Critical thinking, problem solving, and decision making:** **8.1.2.F.1** Use geographic mapping tools to plan and solve problems. **8.2 Technology, Education, Engineering, Design, and Computational Thinking -** Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and	**CRP1.** Act as a responsible and contributing citizen and employee. **CRP2.** Apply appropriate academic and technical skills. **CRP3.** Attend to personal health and financial well-being. **CRP4.** Communicate clearly and effectively and with reason. **CRP5.** Consider the environment, social and economic impacts of decisions. **CRP6.** Demonstrate creativity and innovation. **CRP7.** Employ valid and reliable research strategies. **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them. **CRP9.** Model integrity, ethical leadership and effective management. **CRP10.** Plan education and career paths aligned to personal goals. **CRP11.** Use technology to enhance productivity. **CRP12.** Work productively in teams while using cultural global competence. **Strand B. Money Management** **9.1.4.B.1** Differentiate between financial wants and needs. **9.1.4.B.2** Identify age-appropriate financial goals **9.1.4.B.3** Explain what a budget is and why it is important. **9.1.4.B.4** Identify common household expense categories and sources of income. **9.1.4.B.5** Identify ways to earn and save. **Strand C. Credit and Debt Management** **9.1.4.C.1** Explain why people borrow money and the relationship between credit and debt. **Strand D. Planning, Saving, and Investing** **9.1.4.D.1** Determine various ways to save. **9.1.4.D.2** Explain what it means to "invest." **9.1.4.D.3 Distinguish between saving and investing.** **Strand E. Becoming a Critical Consumer** **9.1.4.E.1** Determine factors that influence consumer decisions related to money. **9.1.4.E.2** Apply comparison shopping skills to purchasing decisions. **Strand F. Civic Financial Responsibility** **9.1.4.F.1** Demonstrate an understanding of individual financial obligations and community financial obligations. **9.1.4.F.2** Explain the roles of philanthropy, volunteer service, and charitable contributions, and analyze their impact on community development and quality of living. **9.2 Career Awareness, Exploration, and Preparation**

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the designed world as they relate to the individual, global society, and the environment. **A. The Nature of Technology: Creativity and Innovation** **8.2.2.A.1** Define products produced as a result of the technology or of nature. **8.2.2.A.2** Describe how designed products and systems are useful at school, home or work. **8.2.2.A.3** Identify a system and the components that work together to accomplish its purpose. **8.2.2.A.4** Choose a product to make and plan the tools and material needed. **8.2.2.A.5** Collaborate to design a solution to a problem affecting the community. **B. Technology and Society:** **8.2.2.B.1** Identify how technology impacts or improves life. **8.2.2.B.2** Demonstrate how reusing a product affects the local and global environment. **8.2.2.B.3** Identify products or systems that are designed to meet human needs. **8.2.2.B.4** Identify how the ways people live and work has changed because of technology. **C. Design:** **8.2.2.C.1** Brainstorm ideas on how to solve a problem or build a product. **8.2.2.C.2** Create a drawing of a product or device that communicates its function to peers and discuss. **8.2.2.C.3** Explain why we need to make new products. **8.2.2.C.4** Identify designed products and brainstorm how to improve one used in the classroom. **8.2.2.C.5** Describe how the parts of a common toy or tool interact and work as part of a system. **8.2.2.C.6** Investigate a product that has stopped working and brainstorm ideas to correct the problem. **D. Abilities for a Technological World:** **8.2.2.D.1** Collaborate and apply a design process to solve a simple problem from everyday experiences. **8.2.2.D.2** Discover how a product works by taking it apart, sketching how parts fit, and putting it back together. **8.2.2.D.3** Identify the strengths and weaknesses in a product or system. **8.2.2.D.4** Identify the resources needed to create technological products or systems. **8.2.2.D.5** Identify how using a tool (such as a bucket or wagon) aids in reducing work. **E. Computational Thinking: Programming** **8.2.2.E.1** List and demonstrate the steps to an everyday task.	**9.2.4.A.1** Identify reasons why people work, different types of work, and how you can help a person achieve personal and professional goals. **9.2.4.A.2**. Identify various life roles and civic and work-related activities in the school, home and community. **9.2.4.A.3** Investigate both traditional and nontraditional careers and relate information to personal likes and dislikes. **9.2.4.A.4** Explain why knowledge and skills acquired in the elementary grades lay the foundation for future academic and career success.

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8.2.2.E.2 Demonstrate an understanding of how a computer takes input through a series of written commands and then interprets and displays information as output. **8.2.2.E.3** Create a set of instructions) using a predefined set of commands (e.g., to move a student or character through a maze). **8.2.2.E.4** Debug an algorithm (i.e., correct an error). **8.2.2.E.5** Use appropriate terms in conversation (e.g., basic vocabulary words: input, output, the operating system, debug and algorithm).	

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ASSESSMENTS

NJ STATE SCIENCE ASSESSMENT:
New Jersey Student Learning Assessment for Science (NJSLA-S): The NJSLA-S is the state science test for New Jersey public school students in grade 5, grade 8, and grade 11. This link provides access to detailed information about these assessments.

FORMATIVE ASSESSMENTS:
Formative assessment, including diagnostic testing, is a range of formal and informal assessment procedures conducted by teachers during the learning process in order to modify teaching and learning activities to improve student attainment. It typically involves qualitative feedback (rather than scores) for both student and teacher that focuses on the details of content and performance. NOTE: Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.

In-class discussions
PowerPoint group presentations
Group debates
Portfolios
Notebooks
Weekly quizzes
Do-Now reflection writing assignments from web-based science articles.
Homework assignments
Surveys
LABs

SUMMATIVE ASSESSMENTS:

Benchmarks which include: Pre-test, Mid-term and Final (**EdConnect**)
Unit Tests
Final Essays
Final Exam
Instructor-created content exams
Final Presentations
Final Projects
Standardized Tests

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Instructional and Supplemental materials

Textbooks

Anatomy & Physiology...Martini/Bartholomew, Essentials of Anatomy & Physiology, 2010. Pearson

Academic Chemistry…………………………………...Wilbraham, Chemistry, 2008. Pearson
Chemistry Honors……………………………………………Modern Chemistry, 2006 Holt
AP Chemistry……………….. ……Petrucci & Harwood, General Chemistry 6th Edition, 1993

Biology Academic………………………………………….…..Modern Biology 2009 by Holt
Biology Honors……………………………………………………..Biology 2009 by Glencoe
AP Biology…………………………………………Campbell and Reece AP Biology 7th Edition

Earth Science……………………Earth Science: Geology and the Environment. 2005 Glencoe.

Environmental Science Academic…………...Withgott, Environmental Science, 2011. Pearson
Marine Science Academic/Honors…………Greene, Marine Science, 2017 Amsco Publications
Environmental Science AP…………………..Withgott, LaPosata, Environment, 2014. Pearson

Forensics……………………………………………………..………No Textbooks Selected
Physics Honors…………………………...…….........Cutnell & Johnson Physics Ed 2015. Wiley
(Electronic version only)
Physics AP…………….Halliday & Resnick, Fundamentals of Physics 10th Edition. 2014 Wiley
(Electronic version only)

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***NOTE: For course specific supplemental and Instructional Materials please goto the Individual Science Specific Curriculum Guide Documents.**

General Science Based - Instructional and Supplemental Science Materials

Audio visual media
Charts, handouts, graphs
Class & individual assignments
Cooperative activities
Critical thinking:
Decision making, Compare & contrast, Reliable sources Causal explanation
Debates & panel discussion
Demonstrations (teacher/student led)
Direct instruction
Discussion (teacher/student led)
Drill practice
Extra credit project or presentation
Homework
Investigation
Laboratory experiment
Lecture
Library and resource documents
Oral reading
Newspapers/Periodicals:
NY Times, Press of Atlantic City Science Section, National Geographic Magazine, Nature Magazine,
Questioning techniques
Research paper
Reviews
Self-instructional instruments
Textbook
Textbook supplements
Tutoring (peer & teacher)

Governmental Web Resources:
United States Geological Survey www.usgs.gov
National Oceanic and Atmospheric Administration, www.noaa.gov
National Aeronautics and Space Administration www.nasa.gov
United States Health Dept. www.hhs.gov
United Sates Department of Agriculture. www.usda.gov
National Science Foundation www.nsf.gov
National Geographic. www.nationalgeographic.com
Discovery, www.discoveryeducation.com
Science Daily, www.sciencedaily.com
Scientific American www.scientificamerican.com
You tube. www.youtube.com
NBC Learn. www.nbclearn.com

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CURRICULUM GUIDES (click of each)

- Biology
- Honors Biology
- AP Biology
- Chemistry
- Honors Chemistry
- AP Chemistry
- Physics
- AP Physics
- Anatomy & Physiology
- Forensics
- Environmental Science
- Earth Science
- Marine Science Honors
- Marine Science Academic

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Integration of technology

Encourage innovative programs and fill gaps in implementation through targeted grant programs.

Maintain the New Jersey Department of Education's portal with pertinent information to inform the educational community in New Jersey and to provide online professional development opportunities for educators.

- Provide web-based resources with information on Internet safety.
- Maintain links to Acceptable Use Policies (AUPs).
- Provide links to sites for community access and adult literacy training centers.

Form strategic partnerships with the education and business community to develop projects and provide resources that will enhance student achievement using educational technology and information literacy skills.

Identify both emerging and promising practices in educational technology implementation that promote equitable access and accessibility and disseminate this information to districts and schools.

Ensure that the New Jersey Department of Education portal will comply with the New Jersey accessibility standards.

Identify and disseminate resources from the federal, state, county, local government, and the private sector to support student, teacher and administrator access to educational technology by participating in workshops, conferences/seminars at national, state, and local levels.

Provide research and policy support for the development and use of online courses and virtual schools by participating in workshops, conferences/seminars at national, state, and local levels.

Provide access to the Internet and multimedia content in all learning environments for students, teachers, administrators and staff.

Form strategic partnerships with other school districts, educational institutions and the business community to share fiscal and programmatic resources.

Collaborate with community resources to establish access beyond the school day.

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Continue to provide and update: high speed LANs (Local Area Network), high speed WANs (Wide Area Network) E-mail use, Technology-infused lesson plans, Productivity software, Inventory of hardware and software

Monitoring network use and end user needs to target technical support activities

- Administrative software
- A safe Internet environment
- Acceptable Use Policies (AUP) for all users
- Maintenance of records that authorize use of a student's personal information on district- or school-based web sites.
- (NJ Bill A592 http://www.state.nj.us/njded/techno/idconsent/).
- Lists of resources for students and parents/legally designated caregivers through Web-based information, community centers, homework hot lines, teacher e-mail, teacher-developed web sites and training/workshops provided by various districts.
- Education of administrators, teachers, and students in the ethical use of computers.

Review school and district web sites in relation to alignment with New Jersey's state accessibility statements.

Facilitate communication between informational technology, educational technology, assistive technology and curriculum professionals so that the district's technological resources can be used to support the learning and achievement of all students.

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Career Education
21st Century Life and Careers

In today's global economy, students need to be lifelong learners who have the knowledge and skills to adapt to an evolving workplace and world. To address these demands, Standard 9, 21st Century Life and Careers, which includes the 12 Career Ready Practices, establishes clear guidelines for what students need to know and be able to do in order to be successful in their future careers and to achieve financial independence.

Mission: *21st century life and career skills enable students to make informed decisions that prepare them to engage as active citizens in a dynamic global society and to successfully meet the challenges and opportunities of the 21st century global workplace.*

Vision: To integrate 21st Century life and career skills across the 9-12 curriculum and in Career and Technical Education (CTE) programs to foster a population that:

- Continually self-reflects and seeks to improve the essential life and career practices that lead to success.
- Uses effective communication and collaboration skills and resources to interact with a global society.
- Is financially literate and financially responsible at home and in the broader community.
- Is knowledgeable about careers and can plan, execute, and alter career goals in response to changing societal and economic conditions.
- Seeks to attain skill and content mastery to achieve success in a chosen career path.

The Standards: Standard 9 is composed of the Career Ready Practices and Standard 9.1, 9.2, and 9.3 which are outlined below:

- **The 12 Career Ready Practices**
  These practices outline the skills that all individuals need to have to truly be adaptable, reflective, and proactive in life and careers. These are researched practices that are essential to career readiness.

- **9.1 Personal Financial Literacy**
  This standard outlines the important fiscal knowledge, habits, and skills that must be mastered in order for students to make informed decisions about personal finance. Financial literacy is an integral component of a student's college and

career readiness, enabling students to achieve fulfilling, financially-secure, and successful careers.

- **9.2 Career Awareness, Exploration, and Preparation**
  This standard outlines the importance of being knowledgeable about one's interests and talents, and being well informed about postsecondary and career options, career planning, and career requirements.

- **9.3 Career and Technical Education**
  This standard outlines what students should know and be able to do upon completion of a CTE Program of Study.

For students to be college and career ready they must have opportunities to understand career concepts and financial literacy. This includes helping students make informed decisions about their future personal, educational, work, and financial goals. By integrating Standard 9 into instruction, New Jersey students will acquire the necessary academic and life skills to not only achieve individual success but also to contribute to the success of our society.

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Section V

Appendices - Rubrics

Rubric for Science Assessment Items, Tasks and Prompts

LAB Rubric

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EARTH SCIENCE September						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	Labor Day No School	**Teachers Professional Day**	**Teachers Professional Day**	**Class Mgmt**	**Class Mgmt**	
	No School	**Scientific Method**	**Scientific Method & Problem-Solving**	**Scientific Method & Problem-Solving**	**Earth Science Pre-Test**	
	States of Matter	**States of Matter**	**No School**	**Geographical Areas of the Earth**	**Geographical Areas of the Earth**	
	Using maps and charts	**Using maps and charts**	**Using maps and charts**	**Using maps and charts**	**Using maps and charts**	

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EARTH SCIENCE October						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
		Layers of Earth's Atmosphere	**Layers of Earth's Atmosphere**	**Layers of Earth's Atmosphere**	**Earth's Atmosphere Ozone**	
	Columbus Day No School	**Earth's Atmosphere and Solar Energy**	**Earth's Atmosphere and Solar Energy**	**What is Weather**	**Cloud and wind Patterns**	
	Weather Fronts	**Weather Forecasting**	**Weather Forecasting**	**Weather Forecasting**	**Severe Weather**	
	Severe Weather	**Global Warming and Climate Change**	**Global Warming and Climate Change**	**Global Warming and Climate Change**	**Global Warming and Climate Change**	
	Earth's Oceans					

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EARTH SCIENCE November						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
				Earth's Oceans, Currents and Atmosphere	**Earth's Oceans Currents and Atmosphere**	
	Earth's Oceans El Nino-La Nina	**Election Day**	**Earth's Oceans El Nino-La Nina**	**NJEA Convention**	**NJEA Convention**	
	Wave Formation	**Wave Formation**	**Tides**	**Tides**	**Earth's Tilt and Rotation**	
	Types of Coastlines	**Types of Coastlines**	**Types of Coastlines**	**Thanksgiving Day**	**Thanksgiving Day**	
	Seafloor Features	**Seafloor Features**	**Classification of Marine Organisms**			

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EARTH SCIENCE December						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	Ocean Energy, Photosynthesis	**Marine Life**	**Marine Mammals**	**Marine Mammals**	**Sharks**	
	Sharks	**Coral Reefs**	**Coral Reefs**	**Ocean Pollution**	**Oil Remediation**	
	Ocean and Humans	**Ocean and Humans**	**Ocean and Humans**	**Ocean and Humans**	**Ocean and Humans**	
25	**26** **Winter Recess**	**27** **Winter Recess**	**28** **Winter Recess**	**29** **Winter Recess**	**30** **Winter Recess**	31

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EARTH SCIENCE January						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
			Earth Processes: Erosion-Mass Wasting	**Types of Erosion: Water**	**Types of Erosion: Wind**	
	Types of Erosion: Gravity (Mass Wasting)	**Types of Erosion: Glaciers**	**How is soil formed?**	**What is Soil?**	**Soil Types**	
	Soil Horizons	**Earth's Hydrosphere**	**Water Cycle**	**River Systems: Flood plains, Deltas**	**River Systems: Flood plains, Deltas**	
	Dr. MLK Jr. No School	**Watersheds wells, water table**	**BENCHMARK MID-TERM**	**BENCHMARK MID-TERM**	**BENCHMARK MID-TERM**	
	GIS Systems	**What is Land Use?**	**Types of Land Use**	**Land Use and geographical features.**		

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EARTH SCIENCE February						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
					Rock Cycle	
	Types of Rocks Igneous	**Types of Rocks Metamorphic**	**Types of Rocks Metamorphic**	**Types of Rocks Sedimentary**	**Types of Rocks Sedimentary**	
	What are Minerals?	**Rock & Mineral Identification**	**How are minerals used?**	**What are Fossil Fuels?**	**Coal, Oil and Natural Gas**	
	Presidents Day No School	**Layers of the Earth**	**Layers of the Earth?**	**What is Plate Tectonic Theory?**	**Plate Tectonics**	
	Seafloor spreading	**Seafloor spreading**	**How are mountains formed?**	**Types of Mountains**		

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EARTH SCIENCE March						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
					Location of most mountain ranges.	
	What are Earthquakes?	**What are Earthquakes?**	**Epi-center, seismic waves Intensity, tracking**	**Preventing earthquake damage**	**Major Earthquakes through Time**	
	What are Volcanoes?	**Types of Volcanic eruptions**	**Formation of Volcanoes**	**History of Major Volcanoes**	**Anthropogenic effect of volcanic eruptions**	
	Volcanic activity and geothermal energy	**Volcanic activity and geothermal energy**	**Relationships of Earthquakes and Volcanoes**	**NO SCHOOL for Students**	**Tidal waves-tsunamis**	
	Tidal waves-tsunamis	**Other Earth Processes**	**Geologic Time**	**Geologic Time**	**Geologic Timeline Epochs and Eras**	

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EARTH SCIENCE April						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	What are Fossils?	**Fossil types**	**Where are fossils found?**	**How do we Date the age of fossils?**	**Carbon 14 dating.**	
	What caused the extinction of the Dinosaurs?	**What are the previous extinction events?**	**What is the sixth Extinction?**	**How can humans slow down the rate of extinction**	**How can humans slow down the rate of extinction**	
	Our Sun and the Solar System	**Our Sun and the Solar System**	**The Earth from Space**	**The Earth from Space**	**SPRING RECESS**	
	SPRING RECESS	**SPRING RECESS**	**SPRING RECESS**	**SPRING RECESS**	**SPRING RECESS**	
	Earth-Moon System	**Earth-Moon System**				

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EARTH SCIENCE May						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
			Earth-Moon System	**Lunar Phases**	**Lunar Exploration**	
	Our Sun and the Solar System	**Our Sun and the Solar System**	**Mercury, Venus**	**Mars**	**Mars Exploration**	
	Jupiter	**Jupiter Exploration**	**Saturn**	**Saturn Exploration**	**Outermost planets**	20
	Space Exploration	**Space Exploration of the future**	**How did the Universe Form?**	**What is the Big Bang Theory?**	**How did the Galaxies form?**	27
	MEMORIAL DAY No School	**Star formation and Identification**	**Exploring Deep Space**	**Space Technology**	**Space Technology**	

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EARTH SCIENCE June						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	Future of Astronomy	**Future of Astronomy**	**Future of Astronomy**	**Future of Astronomy**	**No School for Students**	
	REVIEW and FINAL EXAM BENCHMARK	**REVIEW and FINAL EXAM BENCHMARK**	**REVIEW and FINAL EXAM BENCHMARK**	**REVIEW and FINAL EXAM BENCHMARK**	**REVIEW and FINAL EXAM BENCHMARK**	
	Half Day	**Half Day**	**Half Day**	**Half Day**	**Proposed Last Day of school**	

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MARINE SCIENCE September						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	Labor Day No School	Teachers Professional Day	Teachers Professional Day	Class Mgmt	Class Mgmt	
	No School	Intro to Marine Science	Intro to Marine Science	Oceanography	Oceanography Marine Science Pre-Test	
	UW Technology Marine Science Pre-Test	UW Technology Marine Science Pre-Test	No School	Shipwrecks & Archaeology Marine Science Pre-Test	Shipwrecks & Archaeology	
	Using maps and charts	Using maps and charts	Scientific Method & Problem-Solving	Scientific Method & Problem-Solving	Scientific Method & Problem-Solving	

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MARINE SCIENCE
October

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		What is Water?	What is Water?	What is Water?	What is Water?	
	Columbus Day No School	Earth's Oceans	Earth's Oceans	Geology and the Oceans	Types of Coastlines	
	Plate Tectonics	Plate Tectonics	Seafloor Spreading	Seafloor Features	Volcanoes, Ring of Fire	
	Volcanoes, Ring of Fire	Earthquakes & Tsunamis	Earthquakes & Tsunamis	The Abyss	The Abyss	
	The Abyss					

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MARINE SCIENCE **November**						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
				Earth's Oceans, Currents and Atmosphere	**Earth's Oceans Currents and Atmosphere**	
	Earth's Oceans, Currents and Atmosphere	**Election Day**	**Earth's Oceans, Currents and Atmosphere**	**NJEA Convention**	**NJEA Convention**	
	Oceans Energy	**Weather vs. Climate**	**Weather vs. Climate**	**Coriolis Effect**	**Water Cycle**	
	Air masses, Winds, and Circulations	**Hurricanes and Cyclones and Typhoons**	**Hurricanes**	**Thanksgiving Day**	**Thanksgiving Day**	
	Greenhouse Effect, Ozone and UV Radiation.	**Climate & Global Warming**	**Climate & Global Warming**			

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MARINE SCIENCE December						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	Ocean Energy,	**Water Temperature, salinity, color**	**Water Temperature, salinity, color**	**Pressure & Depth**	**Pressure & Depth**	
	Solar radiation and ocean heating	**Earth's tilt and rotation**	**Specific Heat Land & sea breezes**	**Tides**	**Tides**	
	Ocean Currents	**Ocean Currents**	**Ocean Currents**	**Global Conveyor Belt**	**El Nino-La Nina**	
25	**26** **Winter Recess**	**27** **Winter Recess**	**28** **Winter Recess**	**29** **Winter Recess**	**30** **Winter Recess**	31

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MARINE SCIENCE January						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
			Types of Marine Environments	**Types of Marine Environments**	**Types of Marine Environments**	
	Types of Marine Environments	**Types of Marine Environments**	**Oceans and Biogeochemical cycles**	**Oceans and Biogeochemical cycles**	**Oceans and Biogeochemical cycles**	
	Oceans and Biogeochemical cycles	**Earth's Hydrosphere**	**Water Cycle**	**River Systems: Flood plains, Deltas**	**Ocean energy Photosynthesis**	
	Dr. MLK Jr. No School	**Ocean energy Photosynthesis**	**BENCHMARK MID-TERM**	**Algal Blooms & Dead Zones** **BENCHMARK MID-TERM**	**Zooplankton** **BENCHMARK MID-TERM**	
	Ocean Feeding Relationships **BENCHMARK MID-TERM**	**Ocean Feeding Relationships** **BENCHMARK MID-TERM**	**Ocean Feeding Relationships** **BENCHMARK MID-TERM**	**Ocean Feeding Relationships** **BENCHMARK MID-TERM**		

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MARINE SCIENCE February						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
					Ocean Feeding Relationships **BENCHMARK MID-TERM**	
	Ocean Pollution	**Ocean Pollution Types**	**Ocean Pollution** **Pacific Garbage Patch**	**Oil Spills**	**Ocean Pollution** **Oil Remediation Processes**	
	Ocean Pollution and Ecosystems	**Ocean Pollution and Ecosystems**	**Ocean Pollution** **Effects on Marine life**	**Ocean Pollution** **Effects on Marine life**	**Ocean Pollution** **Effects on Marine life**	
	Presidents Day No School	**Ocean Pollution** **Effects on Maine life/humans**	**Ocean Pollution** **Effects on Maine life/humans**	**Unicellular Organisms:** **Diatoms-Bacteria**	**Unicellular Organisms:** **Diatoms-Bacteria**	
	Marine Algae plants	**Marine Algae plants**	**Plankton Zooplankton**	**Plankton Zooplankton**		

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MARINE SCIENCE March						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
					Intro to Marine Invertebrates	
	Intro to Marine Invertebrates	**Cnidarians**	**Cnidarians**	**Marine Worms**	**Marine Worms**	
	Mollusks	**Mollusks**	**Mollusks**	**Mollusks**	**Mollusks** **Crustaceans**	
	Crustaceans	**Crustaceans**	**Crustaceans**	**NO SCHOOL for Students**	**Echinoderms**	
	Echinoderms	**Echinoderms**	**Oceans DVD**	**Oceans DVD**	**Oceans DVD**	

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MARINE SCIENCE April						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	Introduction to Marine Fishes	**Introduction to Marine Fishes**	**Introduction to Marine Fishes**	**Fish Biology**	**Fish Biology**	
	Niches	**Sharks, Rays and Chimera**	**Sharks, Rays and Chimera**	**Sharks, Rays and Chimera**	**Sharks, Rays and Chimera**	
	Marine Mammals	**Marine Mammals**	**Marine Mammals**	**Marine Mammals**	**SPRING RECESS**	
	SPRING RECESS	**SPRING RECESS**	**SPRING RECESS**	**SPRING RECESS**	**SPRING RECESS**	
	Census of Marine Life and Biodiversity	**Census of Marine Life and Biodiversity**				

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MARINE SCIENCE May						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
			CITES, IUCN Red List	**CITES, IUCN Red List**	**CITES, IUCN Red List**	
	Overfishing Fish Farming	**Overfishing Fish Farming**	**Overfishing Fish Farming**	**Overfishing Fish Farming**	**Overfishing Fish Farming**	
	Ocean and Humans	**Ocean and Humans**	**Ocean and Humans**	**Ocean and Humans**	**Ocean and Humans**	20
	Ocean and Humans	**Ocean and Humans**	**Ocean and Humans**	**Ocean and Humans**	**Ocean and Humans**	27
	MEMORIAL DAY No School	**Ocean and Humans**	**Ocean and Humans**	**Ocean and Humans**	**Ocean and Humans**	

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MARINE SCIENCE June						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	Test Review	**Test Review**	**Test Review**	**Test Review**	**No School for Students**	
	REVIEW and FINAL EXAM BENCHMARK	**REVIEW and FINAL EXAM BENCHMARK**	**REVIEW and FINAL EXAM BENCHMARK**	**REVIEW and FINAL EXAM BENCHMARK**	**REVIEW and FINAL EXAM BENCHMARK**	
	Half Day	**Half Day**	**Half Day**	**Half Day**	**Proposed Last Day of school**	

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ENVIRONMENTAL SCIENCE
SEPTEMBER

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Labor Day	Professional Training	Professional Training	**Half Day Classroom Management	**Half Day Classroom Management
No School	Environmental Science Pre-Test Lesson: Unit 1 Understanding Science 9 days	Environmental Science Pre-Test Lesson: Unit 1 Understanding Science 9 days	Environmental Science Pre-Test Lesson: Unit 1 Understanding Science 9 days	Environmental Science Pre-Test Lesson: Unit 1 Understanding Science 9 days
Environmental Science Pre-Tes Lesson: Unit 1 Understanding Science 9 days	Environmental Science Pre-Test Lesson: Unit 1 Understanding Science 9 days	No School	Lesson: Unit 1 Understanding Science 9 days	Lesson: Unit 1 Understanding Science 9 days
Lesson: Unit 1 Understanding Science 9 days	Unit 2 Earths Structure (9 days)	Unit 2 Earths Structure (9 days)	Unit 2 Earths Structure (9 days)	Unit 2 Earths Structure (9 days)

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ENVIRONMENTAL SCIENCE
OCTOBER

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
	Unit 2 Earths Structure (9 days)	**Unit 2 Earths Structure (9 days)**	**Unit 2 Earths Structure (9 days)**	**Unit 2 Earths Structure (9 days)**
Columbus Day	**Unit 2 Earths Structure (9 days)**	**Yom Kippur**	**Unit 3 Biogeochemical Cycles (14 days)**	**Unit 3 Biogeochemical Cycles (14 days)**
Unit 3 Biogeochemical Cycles (14 days)	**Unit 3 Biogeochemical Cycles (14 days)**	**Unit 3 Biogeochemical Cycles (14 days)**	**Unit 3 Biogeochemical Cycles (14 days)**	**Unit 3 Biogeochemical Cycles (14 days)**
Unit 3 Biogeochemical Cycles (14 days)	**Unit 3 Biogeochemical Cycles (14 days)**	**Unit 3 Biogeochemical Cycles (14 days)**	**Unit 3 Biogeochemical Cycles (14 days)**	**Unit 3 Biogeochemical Cycles (14 days)**
Unit 3 Biogeochemical Cycles (14 days)	**Unit 3 Biogeochemical Cycles (14 days)**	**Unit 4 ECOLOGY (26 days)**		

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ENVIRONMENTAL SCIENCE
NOVEMBER

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
	1	2	3 Unit 4 ECOLOGY (26 days)	4 Unit 4 ECOLOGY (26 days)
7 Unit 4 ECOLOGY (26 days)	8 Election Day	9 Unit 4 ECOLOGY (26 days)	10 NJEA Teacher Convention	11 NJEA Teacher Convention
14 Unit 4 ECOLOGY (26 days)	15 Unit 4 ECOLOGY (26 days)	16 Unit 4 ECOLOGY (26 days)	17 Unit 4 ECOLOGY (26 days)	18 Unit 4 ECOLOGY (26 days)
21 Unit 4 ECOLOGY (26 days)	22 Unit 4 ECOLOGY (26 days)	23 **Half Day Unit 4 ECOLOGY (26 days)	24 Thanksgiving	25 Thanksgiving
28 Unit 4 ECOLOGY (26 days)	29 Unit 4 ECOLOGY (26 days)	30 Unit 4 ECOLOGY (26 days)	Unit 4 ECOLOGY (26 days)	Unit 4 ECOLOGY (26 days)

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ENVIRONMENTAL SCIENCE
DECEMBER

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Unit 4 ECOLOGY (26 days)	**Unit 4 ECOLOGY (26 days)**	**Unit 4 ECOLOGY (26 days)**	**Unit 4 ECOLOGY (26 days)**	**Unit 4 ECOLOGY (26 days)**
Unit 4 ECOLOGY (26 days)	**Unit 4 ECOLOGY (26 days)**	**Unit 4 ECOLOGY (26 days)**	**Unit 5 Human Population (8 Days)**	**Unit 5 Human Population (8 Days)**
Unit 4 ECOLOGY (26 days)	**Unit 5 Human Population (8 Days)**	**Unit 5 Human Population (8 Days)**	**Unit 5 Human Population (8 Days)**	****Half Day** **Unit 5 Human Population (8 Days)**
Winter Break	Winter Break	Winter Break	Winter Break	Winter Break

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ENVIRONMENTAL SCIENCE
JANUARY

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Winter Break	Winter Break	**Unit 6 Human Health 12 days**	**Unit 6 Human Health 12 days**	**Unit 6 Human Health 12 days**
Unit 6 Human Health 12 days	**Unit 6 Human Health 12 days**	**Unit 6 Human Health 12 days**	**Unit 6 Human Health 12 days**	**Unit 6 Human Health 12 days**
Unit 6 Human Health 12 days	**Unit 6 Human Health 12 days**	**Unit 6 Human Health 12 days**	**Unit 6 Human Health 12 days**	**Unit 7 Land Use, Soil & Food (22 Days)**
No School	**Benchmark MID-TERM** Unit 7 Land Use, Soil & Food (22 Days)	**Benchmark MID-TERM** Unit 7 Land Use, Soil & Food (22 Days)	**Benchmark MID-TERM** Unit 7 Land Use, Soil & Food (22 Days)	**Benchmark MID-TERM** Unit 7 Land Use, Soil & Food (22 Days)
Benchmark MID-TERM Unit 7 Land Use, Soil & Food (22 Days)	**Benchmark MID-TERM** Unit 7 Land Use, Soil & Food (22 Days)	Unit 7 Land Use, Soil & Food (22 Days)	Unit 7 Land Use, Soil & Food (22 Days)	

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ENVIRONMENTAL SCIENCE
FEBRUARY

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
				Unit 7 Land Use, Soil & Food (22 Days)
Unit 7 Land Use, Soil & Food (22 Days)	**Unit 7 Land Use, Soil & Food (22 Days)**	**Unit 7 Land Use, Soil & Food (22 Days)**	**Unit 7 Land Use, Soil & Food (22 Days)**	**Unit 7 Land Use, Soil & Food (22 Days)**
Unit 7 Land Use, Soil & Food (22 Days)	**Unit 7 Land Use, Soil & Food (22 Days)**	**Unit 7 Land Use, Soil & Food (22 Days)**	**Unit 7 Land Use, Soil & Food (22 Days)**	**Unit 7 Land Use, Soil & Food (22 Days)**
Presidents Day	**Unit 7 Land Use, Soil & Food (22 Days)**	**Unit 7 Land Use, Soil & Food (22 Days)**	**Unit 8 Water Resources 14 Days**	**Unit 8 Water Resources 14 Days**
Unit 8 Water Resources 14 Days	**Unit 8 Water Resources 14 Days**	**Unit 8 Water Resources 14 Days**	**Unit 8 Water Resources 14 Days**	

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ENVIRONMENTAL SCIENCE
MARCH

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
		1	2	3 **Unit 8 Water Resources 14 Days**
6 **Unit 8 Water Resources 14 Days**	7 **Unit 8 Water Resources 14 Days**	8 **Unit 8 Water Resources 14 Days**	9 **Unit 8 Water Resources 14 Days**	10 **Unit 8 Water Resources 14 Days**
13 **Unit 8 Water Resources 14 Days**	14 **Unit 8 Water Resources 14 Days**	15 **Unit 9 AIR 12 Days**	16 **Unit 9 AIR 12 Days**	17 **Unit 9 AIR 12 Days**
20 **Unit 9 AIR 12 Days**	21 **Unit 9 AIR 12 Days**	22 **Unit 9 AIR 12 Days**	23 **No School for Students**	24 **Unit 9 AIR 12 Days**
27 **Unit 9 AIR 12 Days**	28 **Unit 9 AIR 12 Days**	29 **Unit 9 AIR 12 Days**	30 **Unit 9 AIR 12 Days**	31 **Unit 9 AIR 12 Days**

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ENVIRONMENTAL SCIENCE APRIL

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
3 Unit 10 Energy 15 Days	4 Unit 10 Energy 15 Days	5 **Half Day Unit 10 Energy 15 Days	6 **Half Day Unit 10 Energy 15 Days	7 **Half Day Spring Break Unit 10 Energy 15 Days
10 Unit 10 Energy 15 Days	11 Unit 10 Energy 15 Days	12 Unit 10 Energy 15 Days	13 Unit 10 Energy 15 Days	14 Unit 10 Energy 15 Days
17 Unit 10 Energy 15 Days	18 Unit 10 Energy 15 Days	19 Unit 10 Energy 15 Days	20 Unit 10 Energy 15 Days	21 Unit 10 Energy 15 Days
24 Spring Break	25 Spring Break	26 Spring Break	27 Spring Break	28 Spring Break
Unit 11 WASTE 14 Days	Unit 11 WASTE 14 Days			

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ENVIRONMENTAL SCIENCE
MAY

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
1	**2**	**3** **Unit 11 WASTE 14 Days**	**4** **Unit 11 WASTE 14 Days**	**5** **Unit 11 WASTE 14 Days**
8 **Unit 11 WASTE 14 Days**	**9** **Unit 11 WASTE 14 Days**	**10** **Unit 11 WASTE 14 Days**	**11** **Unit 11 WASTE 14 Days**	**12** **Unit 11 WASTE 14 Days**
15 **Unit 11 WASTE 14 Days**	**16** **Unit 11 WASTE 14 Days**	**17** **Environmental Ethics and Responsibility**	**18** **Environmental Ethics and Responsibility**	**19** **Environmental Ethics and Responsibility**
Environmental Ethics and Responsibility	**Environmental Ethics and Responsibility**	**Environmental Ethics and Responsibility**	**Environmental Ethics and Responsibility**	**Environmental Ethics and Responsibility**
No School	**Finals Review**	**Finals Review**	**Finals Review**	**Finals Review**

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ENVIRONMENTAL SCIENCE
JUNE

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Finals Review	**Finals Review**	**Finals Review**	**Finals Review**	**No School for Students**
FINALS TESTING	**FINALS TESTING**	**FINALS TESTING**	**FINALS TESTING**	**FINALS TESTING**
12 **Half Day **CLASSROOM MANAGEMENT**	**13** **Half Day **CLASSROOM MANAGEMENT**	**14** **Half Day **CLASSROOM MANAGEMENT**	**Half Day **CLASSROOM MANAGEMENT**	**Half Day **Proposed Last Day of School**
19	**20**	**21**	**22**	**23**

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
SEPT	• What is Biology? • What are the major themes in Biology? • What is a multicellular/ unicellular organism? • What is Ecology? • What is Homeostasis? • What is Heredity? • What is Evolution? • What are the characteristics of all living things? • What is the Scientific Method? • What is a Theory? • How is the microscope used in biology? • What are the SI units of measurement?	The Science of Biology • Introduction ○ Science of Biology ○ Themes of Biology • World of Biology ○ Characteristics of Life • Scientific Method ○ Steps of the Scientific Method ○ Tools used in Biology ○ Lab Safety • Microscope and Measurement ○ Light Microscope ○ Units of Measurement	• List the 6 themes in Biology • Discuss relationships between adaptation and evolution • Explain the relationship between hypothesizing, predicting, and experimenting • Describe the methods the scientists used in their work • List 6 characteristics of life • Become familiar with the usage and parts of the microscope	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 1) • Student portfolio, journal • Review sheets • Teacher/student discussion	• Labs: ○ Measurement ○ Data/Graphing ○ Tools of Science ○ Intro to Microscope • Videos: ○ *Invisible World* ○ *Life* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
OCT	• How are Chemistry and Biology related? • What is Matter? • What are atoms composed of? • What is an Element? • What determines an element's properties? • What is an Ion? • What is a Molecule? • Why do atoms form bonds? • How are states of matter determined? • What are Acids and Bases? • How are chemical reactions and energy important to living things? • What is ATP? • Why is H2O so important? • Why make Carbon the "element of life"? • What are the four major organic molecules? • What is an enzyme?	• Composition of Matter: ○ Elements ○ Atoms ○ Compounds ○ Molecules ○ Bonding • Energy ○ States of Matter ○ Free Energy ○ Reactions ▪ Energy transfer ▪ Activation Energy ▪ Enzymes • Solutions ○ Describing Solutions ○ Acids and Bases ○ Aqueous Solutions • Organic Macromolecules ○ Structure & Function ○ Carbohydrates ○ Lipids ○ Proteins ○ Nucleic Acids	• Define and differentiate between elements, atoms, molecules and compounds • Explain the structure of an atom and what determines an atom's stability • Predict the number of bonds an atom can form • Explain the behavior of particles in liquids, solids and gases • Explain how energy is related to living things • Explain how enzymes affect chemical reactions in organisms • Contrast properties of acids and bases • Summarize the polarity of H2O • Describe the structure and function of the four class of organic macromolecules and their significance to organisms	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 2 & 3) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs ○ Atom models ○ Enzymes (liver or detergent) ○ Determining pH ○ Models of Organic Molecules • Videos: ○ *Body Story: Fat* • Organization of student portfolio • Jeopardy game • Articles • Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
NOV	• What are the discoveries that led to the development of the cell theory? • What is the cell theory? • How is cell shape related to cell function? • What are the structures and functions of the organelles? • What are the differences between prokaryotes and eukaryotes? • What are the differences between plant and animals cells? • How does diffusion and osmosis play an important role in cell function?	• Discovery of the cell: ○ Cell Theory ○ Cell Diversity • Eukaryotes ○ Cell Membrane ○ Lipids ○ Proteins ○ Fluid mosaic model • Organelles ○ Structure ○ Function • Passive Transport ○ Diffusion ○ Osmosis ○ Facilitated Diffusion • Active Transport ○ Channels and Pumps ○ Energy Demand	• Outline the discoveries that led to the development of the cell theory • State the cell theory • Distinguish between prokaryotes and eukaryotes • Describe the structure and function of all organelles • Distinguish between osmosis and diffusion. • Distinguish between passive transport and active transport	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch. 4 & 5) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: ○ Cell Model ○ Microscope: Animal vs. Plant ○ Microscope: Check cell ○ Micro-viewers ○ Osmosis and Diffusion Lab Kit • Videos: ○ *Magic of Cells* ○ *Body Story:* various • Organization of student portfolio • Article • Jeopardy game • Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities

DEC	• What is Light?
	• What are Pigments?
	• What is Photosynthesis?
	• What is Carbon Fixation?
	• What materials are consumed/produced from photosynthesis?
	• What is Cellular Respiration?
	• What is Glycolysis?
	• What is Fermentation?
	• How is aerobic respiration related to the structure of the mitochondrion?
	• What materials are consumed/produced from respiration?
		• Capturing Light
		  ○ Light
		  ○ Pigments
		  ○ Photosystems
		• Calvin Cycle
		• Glycolysis and Fermentation
		  ○ Chemical energy
		  ○ Anaerobic pathways
		  ○ Fermentation
		  ○ Lactic acid/Alcohol formation
		• Aerobic respiration
		  ○ Krebs cycle
		  ○ Electron transport
			• Describe the structure of the Chloroplast as it relates to photosynthesis
			• Describe the processes of light capture, electron transport and chemiosmosis
			• Describe how Carbon if fixed via the Calvin Cycle
			• Compare and contrast lactic acid fermentation and alcoholic fermentation
			• Calculate the efficiency of glycolysis.
			• Summarize the events of the Krebs cycle
			• Relate aerobic respiration to the structure of a mitochondrion.
				• Vocabulary quiz
				• Directed Reading
				• OEQ
				• Lab Reports
				• Tests (6 & 7)
				• Student portfolio
				• Review sheets
				• Vocabulary in portfolio
				• Teacher/student discussion
					• Labs:
					  ○ Viewing the Stoma of a Leaf
					  ○ Planting Pea Plants
					• Videos:
					  ○ *Photosynthesis (Standard Deviants)*
					• Organization of student portfolio
					• Articles
					• Jeopardy game
					• Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities

JAN	• How are Chromosomes, Proteins, and DNA related?
	• How many chromosomes does a body cell/ sex cell have?
	• What is Mitosis/Meiosis?
	• Who was Gregor Mendel and how did his work effect the study of genetics?
	• What is the different between dominant and recessive traits?
	• How are genes and alleles similar and alike?
	• How do we calculate the probability of a genetic outcome?
	• What is the difference between a monohybrid and dihybrid cross?
		• Chromosomes
		  ○ Structure
		  ○ Number
		• Cell Division
		  ○ Mitosis
		  ○ Meiosis
		  ○ Crossing over
		• Mendelian Genetics
		  ○ Gregor Mendel and his experiments
		  ○ Dominant traits
		  ○ Recessive traits
		  ○ Law of Segregation
		  ○ Law of Independent Assortment
		  ○ Barbara McKlintock
		• Probability and genetic crosses
		  ○ Genotype
		  ○ Phenotype
		  ○ Monohybrid crosses
		  ○ Dihybrid Crosses
			• Relate Chromosomes, Genes, DNA
			• Explain the structure of a chromosome
			• Distinguish homologous and sex chromosomes
			• Distinguish haploid and diploid cells
			• Describe the cell cycle
			• Describe the process of Mitosis, Meiosis
			• Understand Gregor Mendel's contribution to genetics
			• Model Mendel's experiments with pea plants
			• Differentiate between dominant and recessive traits
			• Differentiate between genes and alleles
			• Use Punnett Squares to calculate the probability of obtaining a certain genetic outcome
				• Vocabulary quiz
				• Directed Reading
				• OEQ
				• Lab Reports
				• Tests (8 & 9)
				• Student portfolio
				• Review sheets
				• Vocabulary in portfolio
				• Teacher/student discussion
					• Labs:
					  ○ Chromosome beads
					  ○ Microscope: Mitosis: Onion root tip
					  ○ Mitosis/ Meiosis Models
					  ○ Determining Genotypes: Tongue Rolling
					• Videos:
					  ○ *Bill Nye: Genes*
					• Organization of student portfolio
					• Articles
					• Jeopardy game
					• Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
FEB/ MAR	• What is the principal function of DNA? • How does the structure of DNA relate to its function? • What is the role of complimentary base pairing? • How does DNA replicate? • How does RNA compare with DNA? • How does the shape of RNA compare to its function? • What is transcription and how does it relate to protein synthesis? • What factors affect gene expression? • What causes Cancer? • What are some human genetic diseases? • What are some common Biotechnology techniques?	• Discovery of DNA • DNA shape and function ○ DNA components ○ Complementary base pairing • DNA replication • RNA shape and function ○ RNA components ○ The 3 types of RNA • Transcription and Translation • Gene Expression ○ Cancer • Human Genetics ○ Patterns of Inheritance ○ Pedigrees ○ Genetic Diseases • DNA Technology ○ recombinant DNA ○ DNA fingerprint ○ Pharmaceuticals, Agriculture ○ Bioethics	• Identify DNA and its components • Describe the shape of DNA • Explain how base pairs match each other • Identify the process of DNA replication • Transcribe sequences of DNA to RNA • Translate sequences of RNA into amino acids • Describe protein folding • Describe factors that affect gene expression • Describe chromosome and gene mutations • Describe common genetic disorders and their cause • Create and use pedigrees • Describe the process of creating a transgenic organism • Discuss the ethical questions that arise in biotechnology	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch. 10) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: ○ DNA Model ○ DNA Extraction ○ Taste- Pedigree • Videos: ○ *Gattaca* ○ *Twins (Discovery Channel)* ○ *Rosaline Franklin* ○ *The Island* ○ *Jurassic Park* • Project: ○ Bioethics essay ○ Biotechnology Power Point • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
MAR/ APRIL	• How old is the Earth? • What is radioactive dating? • How did organic compound arise? • What are the oldest know organisms? • What is evolution? • How do fossils give us evidence of evolution? • How did Darwin contribute to the theory of evolution? • What is the evidence for evolution? • How does natural selection drive evolution? • How do paleoanthropologists gather evidence of human ancestry? • What are Primates? • What are Hominids? • What is the current map of human evolution?	• Earth's History ○ Formation ○ Radioactive Dating ○ Life from nonliving chemicals ○ Urey and Miller ○ First organisms ○ Endosymbiosis • Geological time periods • Fossils and the fossil record ○ Law of superposition • Descent with modification • Evolution and its evidence, definition, and social impact. • Charles Darwin • Natural selection • Evidence ○ Homologous, analogous, and vestigial structures ○ Coevolution, divergent evolution, and convergent evolution • Primate Characteristics • Hominid Evolution ○ Fossil Evidence ○ Phylogenic Trees	• Describe how the age of the Earth is determined • Describe Urey and Miller's experiment • Describe the theory of how replicating chemicals could have evolved into the first cells • Describe the theory of endosymbiosis • Describe fossil formation • Give several pieces of evidence supporting evolution • Tell how biogeography suggests descent with modification • Explain Darwin's two major theories • Explain the process of Natural Selection • Describe primate characteristics • Describe australopithecies • Describe species of the genus *Homo* • Describe the current map of human evolution?	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 14, 15 &17) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: ○ Natural Selection • Videos: ○ *Walking with…*series ○ *Bill Nye: Greatest Discoveries: Evolution* ○ *Nova: Evolution on Trial* ○ *Inherit the Wind* ○ *Neanderthal* ○ *Land of Monsters* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
APRIL/ MAY	• Why is Ecology important? • What are some human caused environmental problems? • How are Communities, Populations and Organisms connected? • What is a niche? • What is symbiosis? • How do predators differ from parasites? • What is Succession? • How does energy flow through an ecosystem? • How does water cycle through an ecosystem? • How does carbon cycle through an ecosystem? • What are the 7 major Biomes?	• Ecology ○ Environmental changes ○ Levels of organization • Ecology of Organisms ○ Habitat ○ Biotic and abiotic factors ○ Niche • Community Ecology ○ Predation ○ Parasitism ○ Competition ○ Mutualism and Commensalism • Properties of Communities • Succession • Energy Transfer ○ Producers/ Consumers ○ Food webs • Ecosystem Recycling ○ Water cycle ○ Carbon cycle ○ Nitrogen cycle • Terrestrial Ecosystems ○ Biomes • Aquatic Ecosystems	• Define ecology and explain why it is important • Identify the five different levels of organization in ecology • Explain the theme of interconnectedness • Contrast abiotic factors with biotic factors • Explain the concept of a Niche • Distinguish predation from parasitism • Describe how plants can defend themselves against herbivores • Explain the difference between species richness and species diversity • Distinguish between primary and secondary succession • Describe how energy flows through an ecosystem • Trace the steps of the water, carbon, and nitrogen cycles	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: ○ Microscope: Pond Water ○ Observing Ecology • Video: • Organization of student portfolio • Article • Jeopardy game • Notes/ class discussion

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Name: ACADEMIC BIOLOGY TEACHERS Course: Academic Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
MAY/ JUNE	• How has the classification of organisms changed over the past? • What are the modern criteria for classifying organisms? • How did Aristotle's classification system work? • In what ways was his system different than Linnaeus's? • What are the primary criterion that modern taxonomists use to classify organisms?	• Taxonomy • Carolus Linneaus • Morphology • 7 class system of classification • Binomial nomenclature • Phylogeny • Cladistic	• Describe Aristotle's classification system and explain why it was replaced • Explain Linnaeus's system of classification and identify the main criterion he used to classify organisms • Name the primary criterion that modern taxonomists consider • List four types of evidence used to organize organisms in systematic taxonomy • Explain cladistic taxonomy	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 18) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs • Videos • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Course: AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
Sept.	**A-1**. How do the unique properties of water make life on earth possible? **A-2**. How do the structures of biologically important molecules account for their functions? **A-3**. How do the laws of thermodynamics relate to the processes that provide energy to living systems? **A-4**. How do enzymes regulate the rate of chemical reactions? **B-1**. What are the similarities and differences between prokaryotic and eukaryotic cells? **B-2**. How does the structural organization of membranes provide for cellular transport and recognition? **B-3**. How do organelles function together in cellular processes? **B-4**. How does the cell cycle assure genetic continuity?	**A. Chemistry of Life:** 1. Water 2. Organic molecules 3. Free Energy 4. Enzymes **B. Cells:** 1. Prokaryotic vs. Eukaryotic 2. Membranes 3. Subcellular organization 4. Cell cycle and its regulation **Resources:** Campbell's Biology 4th edition AP Lab Curriculum	**A:** 1. Explain the relationship between the polar nature emergent properties essential to life. 2. Explain the importance of the carbon atom to organic compounds. 3. Explain how organic polymers contribute to biological diversity. 4. Discuss the importance of organic polymers in relation to cellular structure and function. 5. Explain the role of ATP and enzymes in metabolic reactions. **B:** 1. Describe the structure and relationships among the components of the endomembrane system. 2. Describe the fluid-mosaic model of the cell membrane. 3. Describe several mechanisms of cellular transport. 4. Describe the phases of the cell cycle	**A-B:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. PreLab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs (1A,2, and 3A) 4. Homework Questions (Free response and multiple choice)

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Course: AP Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
Oct.	**C-1**. How are organic molecules broken down by catabolic pathways? **C-2**. What is the role of oxygen in energy-yielding pathways? **C-3**. How do cells generate ATP in the absence of oxygen? **C-4**. How does photosynthesis convert light energy into chemical energy? **C-5**. What kinds of photosynthetic adaptations have evolved in response to different environmental conditions? **D-1**. Why is meiosis important in heredity? **D-2**. How is genetic information organized in the eukaryotic chromosome? **D-3**. How does this organization contribute to both continuity and variability of genetic information? **D-4**. What are the principal patterns of inheritance?	**C. Cellular Energetics:** 1. Coupled Reactions 2. Cellular respiration and fermentation 3. Photosynthesis **D. Heredity:** 1. Meiosis 2. Eukaryotic chromosomes 3. Inheritance patterns **Resources:** Campbell's Biology 4th edition AP Lab Curriculum	**C:** 1. Explain energy flow through the biosphere. 2. Distinguish between substrate-level phosphorylation and oxidative phosphorylation. 3. Explain why fermentation is necessary. 4. List the components of a photosystem and explain their function. 5. Describe the light and dark reactions of photosynthesis. 6. Describe two important photosynthetic adaptations to minimize photorespiration. **D:** 1. List the phases of Meiosis I and II and describe the events characteristic of each phase. 2. State Mendel's three laws and indicate the evidence that led him to each. 3. Explain the chromosomal basis of inheritance	**C-D:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. Pre-Lab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs (4A and 5) 4. Homework Questions (Free response and multiple choice)

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Course:__AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
Nov-Dec.	**E-1.** How do the structures of nucleic acids relate to their functions of information storage and protein synthesis? **E-2.** What are the mechanisms by which gene expression is regulated in prokaryotes and eukaryotes? **E-3.** In what ways can genetic information be altered and what are their possible effects? **E-4.** What are the major steps in viral reproduction? **E-5.** What are some current recombinant DNA technologies and what are their applications? **F-1.** What are the current models that explain the origins of prokaryotic and eukaryotic cells? **F-2.** What types of evidence support evolutionary theory? **F-3.** What mechanisms account for speciation and macroevolution?	**E. Molecular Genetics:** 1. RNA and DNA structure and function 2. Gene regulation 3. Mutation 4. Viral structure and replication 5. Nucleic acid technology and applications **F. Evolutionary Biology:** 1. Early evolution of life 2. Evidence for evolution 3. Mechanisms of Evolution. **Resources:** Campbell's Biology 4th edition AP Lab Curriculum	**E:** 1. Describe the structure of DNA and RNA. 2. Describe the processes of DNA replication, RNA transcription, and protein synthesis. 3. Describe how mutagenesis can occur and their potential effects. 4. Distinguish between the lytic and lysogenic reproductive cycles of a virus. 5. Describe the operon model of gene regulation. 6. Describe some practical applications of recombinant DNA technology. **F:** 1. Provide evidence to support the hypothesis that chemical evolution resulting in life's origin occurred in four stages. 2. Discuss evidence that is used to support evolutionary change. 3. Describe mechanisms of evolutionary change.	**E-F:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. PreLab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs 4. Homework Questions (Free response and multiple choice)

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Course: AP Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
Jan.	**G-1.** What are the distinguishing characteristics of each kingdom, and the major phyla of each? **G-2.** How are evolutionary relationships determined among organisms and how is this information used in classification? **H-1.** What is the adaptive significance of alternation of generations in the major groups of plants? **H-2.** What are the patterns of reproduction and development in plants? **H-3.** How does the organization of cells, tissues, and organs determine structure and function in plant systems? **H-4.** What are the responses of plants to environmental cues, and how do hormones mediate them?	**G. Diversity of Life** 1. Evolutionary patterns. 2. Survey of the diversity of life. 3. Phylogenetic classification. 4. Evolutionary relationships. **H. Structure and Function of Plants** 1. Reproduction, growth, and development. 2. Structural, physiological, and behavioral adaptations. 3. Response to the environment. **Resources:** Campbell's Biology 4th edition AP Lab Curriculum	**G:**1. Trace the evolutionary history of life on earth. 2. Identify the distinguishing characteristics of each kingdom and their major phyla. **H:**1. Describe the structure and arrangement of the three plant tissues systems in roots and shoots. 3. Describe how primary and secondary growth occur. 4. Describe differences between monocots and dicots. 5. Describe the mechanisms of plant transport. 6. Describe fertilization in flowering plants. 7. Describe adaptations that promote the dispersal of seeds. 8. Describe the process of seed germination in monocots and dicots. 9. Describe the role of plant hormones in environmental response.	**G-H:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. Pre-Lab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs 4. Homework Questions (Free response and multiple choice)

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Course: __AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
Feb.	**I-1.** How are structure and function related in the various organ systems? **I-2.** How do the organ systems of animal interact? **I-3.** What adaptive features have contributed to the success of animal life? **I-4.** What are the responses of animals to environmental cues, and how do hormones mediate them?	**I. Structure and Function of Animals** 1. Nutrition, Circulation, and Gas Exchange. 2. Defense mechanisms and homeostasis. **Resources:** Campbell's Biology 4th edition AP Lab Curriculum	**I:** 1. Describe some advantages that complete digestive tracts have over gastro vascular cavities. 2. Name and describe the structure and functions of the major organs of the mammalian digestive system. 3. Distinguish between open and closed circulatory systems. 4. Identify ways in which the structures of the circulatory and respiratory systems are related to their functions of transport and gas exchange. 5. Describe the multiple mechanisms of mammalian defense against infectious disease. 6. Describe the various means of osmoregulation and thermoregulation in animals.	**I:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. Pre-Lab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs 4. Homework Questions (Free response and multiple choice)

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Course:__AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
March.	**I-1.** How are structure and function related in the various organ systems? **I-2.** How do the organ systems of animals interact? **I-3.** What adaptive features have contributed to the success of animal life? **I-4.** What are the responses of animals to environmental cues, and how do hormones mediate them?	**I. Structure and Function of Animals** 3. Chemical signals in animals. 4. Reproduction, growth, and development. 5. Nervous systems and sensory mechanisms. **Resources:** Campbell's Biology 4th edition AP Lab Curriculum	**I:**7. Describe the structural and functional relationships among endocrine system components. 8. Describe the structures and functions of the male and female reproductive systems, as well as the phases of the menstrual cycle. 9. Describe the process of fertilization and the development of the human embryo and fetus during the three trimesters of pregnancy. 10. Describe the structural and functional relationships among nervous system components. 11. Describe the structural and functional relationship between the sensory organs and the central nervous system. 12. Describe the functions of the skeleton and the structural and functional relationship of skeletal muscle and movement.	**I:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. Pre-Lab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs 4. Homework Questions (Free response and multiple choice)

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Course:__AP_Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
April May/June	**J-1.** What models are useful in describing the growth of a population? **J-2.** How is population size regulated by abiotic and biotic factors? **J-3.** How is energy flow through an ecosystem related to trophic structure? **J-4.** How do elements cycle through an ecosystem? **J-5.** How do biotic and abiotic factors affect community structure and ecosystem function? **J-6.** How do organisms affect biogeochemical cycles? **J-7.** What current theories explain the observed behaviors of animals? **K.** Review for AP Exam	**J. Ecology:** 1. Population dynamics 2. Communities and ecosystems 3. Global issues 4. Behavior **K. Units A-J (I-X):** 1. Practice Tests 2. Topic Outline **Resources:** Campbell's Biology 4th edition AP Lab Curriculum Released AP Exams	**J:**1. Differentiate between J-shaped and S-shaped population growth curves, and explain the phases of population growth they illustrate. 2. Distinguish between density-dependent and density-independent factors, and explain how each may limit population growth. 3. Distinguish between intraspecific and interspecific competition. 4. Distinguish between primary and secondary succession and give examples of each. 5. Define trophic level and describe their importance to understanding the structure of an ecosystem. 6. Define biogeochemical cycle and describe the four types. 7. Discuss the various theories of behavioral ecology.	**J:** 1. Daily Quizzes (Fill-in-the blank and Free Response) 2. Weekly Tests and Unit Exams (Multiple Choice and Free Response) 3. Class Discussion (Question/Answer) 4. Pre-Lab Assignments 5. Lab Reports 6. Homework 7. Projects	1. Class Discussion (Question/Answer) 2. Class Notes 3. AP Labs 4. Homework Questions (Free response and multiple choice)

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities

SEPT	• What is Biology?
	• What are the major themes in Biology?
	• What is a multicellular/ unicellular organism?
	• What is Ecology?
	• What is Homeostasis?
	• What is Heredity?
	• What is Evolution?
	• What are the characteristics of all living things?
	• What is the Scientific Method?
	• What is a Theory?
	• How is the microscope used in biology?
	• What are the SI units of measurement?
		The Science of Biology
		• Introduction
		  ○ Science of Biology
		  ○ Themes of Biology
		• World of Biology
		  ○ Characteristics of Life
		• Scientific Method
		  ○ Steps of the Scientific Method
		  ○ Tools used in Biology
		  ○ Lab Safety
		• Microscope and Measurement
		  ○ Light Microscope
		  ○ Units of Measurement
			• List the 6 themes in Biology
			• Discuss relationships between adaptation and evolution
			• Explain the relationship between hypothesizing, predicting, and experimenting
			• Describe the methods the scientists used in their work
			• List 6 characteristics of life
			• Become familiar with the usage and parts of the microscope
				• Vocabulary quiz
				• Directed Reading
				• OEQ
				• Lab Reports
				• Tests (Ch 1)
				• Student portfolio, journal
				• Review sheets
				• Teacher/student discussion
					• Labs:
					  ○ Measurement
					  ○ Data/Graphing
					  ○ Tools of Science
					  ○ Intro to Microscope
					• Videos:
					  ○ *Invisible World*
					  ○ *Life*
					• Organization of student portfolio
					• Articles
					• Jeopardy game
					• Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
OCT	• How are Chemistry and Biology related? • What is Matter? • What are atoms composed of? • What is an Element? • What determines an element’s properties? • What is an Ion? • What is a Molecule? • Why do atoms form bonds? • How are states of matter determined? • What are Acids and Bases? • How are chemical reactions and energy important to living things? • What is ATP? • Why is H2O so important? • Why make Carbon the “element of life”? • What are the four major organic molecules? • What is an enzyme?	• Composition of Matter: ○ Elements ○ Atoms ○ Compounds ○ Molecules ○ Bonding • Energy ○ States of Matter ○ Free Energy ○ Reactions ▪ Energy transfer ▪ Activation Energy ▪ Enzymes • Solutions ○ Describing Solutions ○ Acids and Bases ○ Aqueous Solutions • Organic Macromolecules ○ Structure & Function ○ Carbohydrates ○ Lipids ○ Proteins ○ Nucleic Acids	• Define and differentiate between elements, atoms, molecules and compounds • Explain the structure of an atom and what determines an atom’s stability • Predict the number of bonds an atom can form • Explain the behavior of particles in liquids, solids and gases • Explain how energy is related to living things • Explain how enzymes affect chemical reactions in organisms • Contrast properties of acids and bases • Summarize the polarity of H2O • Describe the structure and function of the four class of organic macromolecules	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 2 & 3) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs ○ Atom models ○ Enzymes (liver or detergent) ○ Determining pH ○ Models of Organic Molecules • Videos: ○ *Body Story: Fat* • Organization of student portfolio • Jeopardy game • Articles • Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities

NOV	• What are the discoveries that led to the development of the cell theory?
	• What is the cell theory?
	• How is cell shape related to cell function?
	• What are the structures and functions of the organelles?
	• What are the differences between prokaryotes and eukaryotes?
	• What are the differences between plant and animals cells?
	• How does diffusion and osmosis play an important role in cell function?
		• Discovery of the cell:
		  ○ Cell Theory
		  ○ Cell Diversity
		• Eukaryotes
		  ○ Cell Membrane
		  ○ Lipids
		  ○ Proteins
		  ○ Fluid mosaic model
		• Organelles
		  ○ Structure
		  ○ Function
		• Passive Transport
		  ○ Diffusion
		  ○ Osmosis
		  ○ Facilitated Diffusion
		• Active Transport
		  ○ Channels and Pumps
		  ○ Energy Demand
			• Outline the discoveries that led to the development of the cell theory
			• State the cell theory
			• Distinguish between prokaryotes and eukaryotes
			• Describe the structure and function of all organelles
			• Distinguish between osmosis and diffusion.
			• Distinguish between passive transport and active transport
				• Vocabulary quiz
				• Directed Reading
				• OEQ
				• Lab Reports
				• Tests (Ch. 4 & 5)
				• Student portfolio
				• Review sheets
				• Vocabulary in portfolio
				• Teacher/student discussion
					• Labs:
					  ○ Cell Model
					  ○ Microscope: Animal vs. Plant
					  ○ Microscope: Check cell
					  ○ Micro-viewers
					  ○ Osmosis and Diffusion Lab Kit
					• Videos:
					  ○ *Magic of Cells*
					  ○ *Body Story:* various
					• Organization of student portfolio
					• Article
					• Jeopardy game
					• Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
DEC	• What is Light? • What are Pigments? • What is Photosynthesis? • What is Carbon Fixation? • What materials are consumed/produced from photosynthesis? • What is Cellular Respiration? • What is Glycolysis? • What is Fermentation? • How is aerobic respiration related to the structure of the mitochondrion? • What materials are consumed/produced from respiration?	• Capturing Light ○ Light ○ Pigments ○ Photosystems • Calvin Cycle • Glycolysis and Fermentation ○ Chemical energy ○ Anaerobic pathways ○ Fermentation ○ Lactic acid/Alcohol formation • Aerobic respiration ○ Krebs cycle ○ Electron transport	• Describe the structure of the Chloroplast as it relates to photosynthesis • Describe the processes of light capture, electron transport and chemiosmosis • Describe how Carbon if fixed via the Calvin Cycle • Compare and contrast lactic acid fermentation and alcoholic fermentation • Calculate the efficiency of glycolysis. • Summarize the events of the Krebs cycle • Relate aerobic respiration to the structure of a mitochondrion.	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (6 & 7) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: ○ Viewing the Stoma of a Leaf ○ Planting Pea Plants • Videos: ○ *Photosynthesis (Standard Deviants)* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities

JAN	• How are Chromosomes, Proteins, and DNA related?
	• How many chromosomes does a body cell/ sex cell have?
	• What is Mitosis/Meiosis?
	• Who was Gregor Mendel and how did his work effect the study of genetics?
	• What is the different between dominant and recessive traits?
	• How are genes and alleles similar and alike?
	• How do we calculate the probability of a genetic outcome?
	• What is the difference between a monohybrid and dihybrid cross?
		• Chromosomes
		  ○ Structure
		  ○ Number
		• Cell Division
		  ○ Mitosis
		  ○ Meiosis
		  ○ Crossing over
		• Mendelian Genetics
		  ○ Gregor Mendel and his experiments
		  ○ Dominant traits
		  ○ Recessive traits
		  ○ Law of Segregation
		  ○ Law of Independent Assortment
		  ○ Barbara McKlintock
		• Probability and genetic crosses
		  ○ Genotype
		  ○ Phenotype
		  ○ Monohybrid crosses
		  ○ Dihybrid Crosses
			• Relate Chromosomes, Genes, DNA
			• Explain the structure of a chromosome
			• Distinguish homologous and sex chromosomes
			• Distinguish haploid and diploid cells
			• Describe the cell cycle
			• Describe the process of Mitosis, Meiosis
			• Understand Gregor Mendel's contribution to genetics
			• Model Mendel's experiments with pea plants
			• Differentiate between dominant and recessive traits
			• Differentiate between genes and alleles
			• Use Punnett Squares to calculate the probability of obtaining a certain genetic outcome
				• Vocabulary quiz
				• Directed Reading
				• OEQ
				• Lab Reports
				• Tests (8 & 9)
				• Student portfolio
				• Review sheets
				• Vocabulary in portfolio
				• Teacher/student discussion
					• Labs:
					  ○ Chromosome beads
					  ○ Microscope: Mitosis: Onion root tip
					  ○ Mitosis/ Meiosis Models
					  ○ Determining Genotypes: Tongue Rolling
					• Videos:
					  ○ *Bill Nye: Genes*
					• Organization of student portfolio
					• Articles
					• Jeopardy game
					• Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities

FEB/ MAR	• What is the principal function of DNA?
	• How does the structure of DNA relate to its function?
	• What is the role of complimentary base pairing?
	• How does DNA replicate?
	• How does RNA compare with DNA?
	• How does the shape of RNA compare to its function?
	• What is transcription and how does it relate to protein synthesis?
	• What factors affect gene expression?
	• What causes Cancer?
	• What are some human genetic diseases?
	• What are some common Biotechnology techniques?
		• Discovery of DNA
		• DNA shape and function
		  ○ DNA components
		  ○ Complementary base pairing
		• DNA replication
		• RNA shape and function
		  ○ RNA components
		  ○ The 3 types of RNA
		• Transcription and Translation
		• Gene Expression
		  ○ Cancer
		• Human Genetics
		  ○ Patterns of Inheritance
		  ○ Pedigrees
		  ○ Genetic Diseases
		• DNA Technology
		  ○ recombinant DNA
		  ○ DNA fingerprint
		  ○ Pharmaceuticals, Agriculture
		  ○ Bioethics
			• Identify DNA and it's components
			• Describe the shape of DNA
			• Explain how base pairs match each other
			• Identify the process of DNA replication
			• Transcribe sequences of DNA to RNA
			• Translate sequences of RNA into amino acids
			• Describe protein folding
			• Describe factors that affect gene expression
			• Describe chromosome and gene mutations
			• Describe common genetic disorders and their cause
			• Create and use pedigrees
			• Describe the process of creating a transgenic organism
			• Discuss the ethical questions that arise in biotechnology
				• Vocabulary quiz
				• Directed Reading
				• OEQ
				• Lab Reports
				• Tests (Ch. 10)
				• Student portfolio
				• Review sheets
				• Vocabulary in portfolio
				• Teacher/student discussion
					• Labs:
					  ○ DNA Model
					  ○ DNA Extraction
					  ○ Taste- Pedigree
					• Videos:
					  ○ *Gattaca*
					  ○ *Twins (Discovery Channel)*
					  ○ *Rosaline Franklin*
					  ○ *The Island*
					  ○ *Jurassic Park*
					• Project:
					  ○ Bioethics essay
					  ○ Biotechnology Power Point
					• Organization of student portfolio
					• Articles
					• Jeopardy game
					• Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
MAR/ APRIL	• How old is the Earth? • What is radioactive dating? • How did organic compound arise? • What are the oldest know organisms? • What is evolution? • How do fossils give us evidence of evolution? • How did Darwin contribute to the theory of evolution? • What is the evidence for evolution? • How does natural selection drive evolution? • How do paleoanthropologists gather evidence of human ancestry? • What are Primates? • What are Hominids? • What is the current map of human evolution?	• Earth's History o Formation o Radioactive Dating o Life from nonliving chemicals o Urey and Miller o First organisms o Endosymbiosis • Geological time periods • Fossils and the fossil record o Law of superposition • Descent with modification • Evolution and its evidence, definition, and social impact. • Charles Darwin • Natural selection • Evidence o Homologous, analogous, and vestigial structures o Coevolution, divergent evolution, and convergent evolution • Primate Characteristis • Hominid Evolution o Fossil Evidence o Phylogenic Trees	• Describe how the age of the Earth is determined • Describe Urey and Miller's experiment • Describe the theory of how replicating chemicals could have evolved into the first cells • Describe the theory of endosymbiosis • Describe fossil formation • Give several pieces of evidence supporting evolution • Tell how biogeography suggests descent with modification • Explain Darwin's two major theories • Explain the process of Natural Selection • Describe primate characteristics • Describe australopithecies • Describe species of the genus *Homo* • Describe the current map of human evolution?	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 14, 15 &17) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: o Natural Selection • Videos: o *Walking with…*series o *Bill Nye: Greatest Discoveries: Evolution* o *Nova: Evolution on Trial* o *Inherit the Wind* o *Neanderthal* o *Land of Monsters* • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS   Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
APRIL/ MAY	• Why is Ecology important? • What are some human caused environmental problems? • How are Communities, Populations and Organisms connected? • What is a niche? • What is symbiosis? • How do predators differ from parasites? • What is Succession? • How does energy flow through an ecosystem? • How does water cycle through an ecosystem? • How does carbon cycle through an ecosystem? • What are the 7 major Biomes?	• Ecology ○ Environmental changes ○ Levels of organization • Ecology of Organisms ○ Habitat ○ Biotic and abiotic factors ○ Niche • Community Ecology ○ Predation ○ Parasitism ○ Competition ○ Mutualism and Commensalism • Properties of Communities • Succession • Energy Transfer ○ Producers/ Consumers ○ Food webs • Ecosystem Recycling ○ Water cycle ○ Carbon cycle ○ Nitrogen cycle • Terrestrial Ecosystems ○ Biomes • Aquatic Ecosystems	• Define ecology and explain why it is important • Identify the five different levels of organization in ecology • Explain the theme of interconnectedness • Contrast abiotic factors with biotic factors • Explain the concept of a Niche • Distinguish predation from parasitism • Describe how plants can defend themselves against herbivores • Explain the difference between species richness and species diversity • Distinguish between primary and secondary succession • Describe how energy flows through an ecosystem • Trace the steps of the water, carbon, and nitrogen cycles • Describe the major terrestrial and aquatic biomes	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs: ○ Microscope: Pond Water ○ Observing Ecology • Video: • Organization of student portfolio • Article • Jeopardy game • Notes/ class discussion

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Name: HONORS BIOLOGY TEACHERS Course: Honors Biology

Month	Essential Questions	Content	Skills	Assessment	Activities
MAY/ JUNE	• How has the classification of organisms changed over the past? • What are the modern criteria for classifying organisms? • How did Aristotle's classification system work? • In what ways was his system different than Linneaus's? • What are the primary criterion that modern taxonomists use to classify organisms?	• Taxonomy • Carolus Linneaus • Morphology • 7 class system of classification • Binomial nomenclature • Phylogeny • Cladistic	• Describe Aristotle's classification system and explain why it was replaced • Explain Linnaeus's system of classification and identify the main criterion he used to classify organisms • Name the primary criterion that modern taxonomists consider • List four types of evidence used to organize organisms in systematic taxonomy • Explain cladistic taxonomy	• Vocabulary quiz • Directed Reading • OEQ • Lab Reports • Tests (Ch 18) • Student portfolio • Review sheets • Vocabulary in portfolio • Teacher/student discussion	• Labs • Videos • Organization of student portfolio • Articles • Jeopardy game • Notes/ class discussion

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PHYSICS						
Month	Essential Question	Content	Skill		Assessment	Activities
Sept.	What is Physics? What are the basic kinematical relationships between position, velocity and acceleration?	Introduction Review Dimensional Analysis The “MKS” system 1 D kinematics	Drawing position vs time graphs Drawing velocity vs time graphs Deriving velocity graphs from position graphs – analyzing the slope of position graph Solving 1 D kinematics problems		Notebook Homework assessment Lab reports and quizzes	Vector Walk Lab. Measuring and plotting accelerated motion with a Bell Timer. Measuring “g” with a Bell Timer. Measuring and plotting constant velocity with a Bell Timer. Conceptual graphing – relating motion to its corresponding position velocity and acceleration graph

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Month	Essential Question	Content	Skill	Assessment	Activities
Oct.	What is a vector? How do vectors combine? What are vector components? How do you determine the components of a vector? What are the application of vectors and vector components? How can motion in 2 D be analyzed?	Introduction The use of arrows to graphically represent vectors How vector addition differs from algebraic addition How vectors and vector components are used to analyze 2 D motion (projectiles)	Drawing vectors to scale Combining vectors with a ruler and triangle by the head to tail method Combing vectors by the parallelogram method Breaking vectors into components with triangle and ruler and by the use of trigonometric functions.	Notebook Homework assessment Lab reports and quizzes	Using a ruler, protractor and triangles to draw, add and resolve vectors Determining the range of a projectile.

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Month	Essential Question	Content	Skill	Assessment	Activities
Nov	What is mass? How is mass measured? What is the difference between inertial mass and gravitational mass? How does mass interact with force? What properties does a moving object have?	Introduction Using the force of gravity to determine the amount of matter. Using the resistance of an object to acceleration as a means of determining mass. An introduction to Newton's 3 laws of motion. Introduction to momentum and kinetic energy	Using a triple beam balance. Using and calibrating an inertial balance. Using a bell timer to measure the acceleration of an object. Using a Pasco "Smart Timer" to measure acceleration.	Notebook Homework assessment Lab reports and quizzes	Lab- Measuring mass with a triple beam balance and an inertial balance. Lab – Determining the relationship between mass, force and acceleration. Lab- Making and testing balloon rockets. (Newton's 3rd law) Lab-Measuring the momentum and kinetic energy of a lab cart./

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Month	Essential Questions	Content	Skills	Assessment	Activities
Dec	How does the Center Mass of a System Behave? How is the Conservation of Linear Momentum Seen in Collisions? What is impulse and how does it relate to Momentum? What does elasticity have to do with collisions? How does rocket propulsion demonstrate the Conservation of Linear Momentum?	Systems of Particles Conservation of Linear Momentum Impulse Collisions - 1 Dimensional - 2 Dimensional - 3 Dimensional Elastic & Inelastic Collisions Rocket Propulsion	Demonstrate how systems of particles behave. Solve elastic and inelastic collision problems Determine what is conserved in various collisions Solve Rocket Problems	Work & Energy Test Rotational Kinematics Tag-Team Competition Rotational Kinematics Test Home Alone Physics Project	“Collisions” Lab “Systems of Particles Motion” Demo “Home-Alone Physics” Project

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Month	Essential Questions	Content	Skills	Assessment	Activities
Jan	How do rotational analogues relate to translational quantities? What is torque and how is it measured? What are the dynamic implications of rotating systems? How is Rotational Inertia calculated for various objects?	Rotational Kinematics Torque – Vector Product Definition Rotational Dynamics Rotational Inertia	Establish the correlation of rotational quantities to translational quantities. Solve torque problems Determine how rotational dynamics cause motion and angular changes in rotating systems Calculate and work with the Rotational Inertia for various objects	Momentum Test Momentum Competition Rotation Test Quiz on Angular Motion Equations	“Rotational Inertia” Lab “Torque” Lab

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Month	Essential Questions	Content	Skills	Assessment	Activities
Feb	What are the requirements and qualities of SHM? How is the Wave Equation derived from a Physical Oscillation? What factors affect the Period of a Spring-Mass Oscillator? What factors affect the Period of a Pendulum? How is Heat Energy Measured? How does a Calorimeter work? How is efficiency measured in a Heat Engine	Simple Harmonic Motion Spring-Mass Oscillations Pendular Oscillations Temperature & Heat Mechanical Equivalence of Heat Calorimetry Heat Engines	Calculate the Period of SHO Convert Temperature to various Scale Measures Calculate MCΔT for Heat Problems Solve Calorimetry Problems Calculate efficiencies of Heat Engines	Check homework solutions "The Pit & the Pendulum" Lab Report "Calorimetry" Lab Test on SHM Test on Heat	"The Pit & The Pendulum" Lab "Calorimetry" Lab

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Month	Essential Question	Content	Skill	Assessment	Activities
	What are the postulates of Special Relativity? What was the state of knowledge in the field of physics when Einstein formulated his theory of Relativity? What is a wave? How does a wave transmit energy How is sound transmitted through air? What is resonance and natural frequency and why are these concepts important.	A historical development of the Special Theory starting with Maxwell's Equations and the problems involving the speed of light. What is time dilation and space contraction? Wave mechanics; parts of a wave and the dynamic characteristics(frequency Period etc.) Sound as a wave phenomena Use the superposition principle to determine the combine wave when waves interfere.	Explain the effect of motion on space and time. Relate the historical development of the Special Theory, being able to explain the context in which it was conceived. List the parts of a wave. Apply the equation for wave speed to determine the frequency, wavelength or speed of a wave. Explain the conditions under which resonance can occur.	Notebook Homework assessment Lab reports and quizzes	View videos on the development of Einstein's equations. Combine waves using the superposition principle. Measure the speed of sound using the resonance of a column of air.

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Month	Essential Questions	Content	Skills	Assessment	Activities
Apr	What is Gauss's Law? What is a Capacitor? What is a Dielectric? How do Capacitors behave in circuits? What contributes to good conductivity in materials? What is superconductance? What is Ohm's Law? How do Series & Parallel Circuits work?	Gauss's Law Capacitors & Dielectrics Material Study Circuits	Solve Gauss's Law Problems Examine & Explain Use of Capacitors Draw Circuit Diagrams Determine Equivalent Resistances	Test on Charge Assessment from the New Jersey Science League – April Test Capacitance Quiz Circuits Test	"Series and Parallel Circuits" Lab "Battery" Lab

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Month	Essential Question	Content	Skill	Assessment	Activities
	What is a field? What are the similarities and differences between electric and gravitational fields? What is an electric fields? What is electric potential? What is a series circuit? What is a parallel circuit? What are the rules for determining the overall resistance of an electric circuit?	Electric fields for point charges are defined using Coulombs law. Electric potential energy is defined and compared to gravitational PE. Electric potential (voltage) is defined Ohm's law is used to define resistance and the fundamental characteristics of an electric circuit. Series, parallel and combination circuits are investigated experimentally.	Students will be able to: Use Coulomb's law to calculate the force between charged objects. .List and apply the rules for electric field lines to properly diagram the electric field around a charged object. Apply Ohm's law to determine the voltage, current flow and resistance of a circuit. Compute the equivalent resistance of series and parallel circuits. Use digital multi-meters to measure current, voltage and resistance Use single use analog meters to measure current, resistance and voltage.	Notebook assessment Homework review Lab reports and lab quizzes.	Demonstration of Van de Graff machine. Lab – constructing simple parallel and series circuits with battery and light bulbs. Lab- Using digital and analog meters to confirm Ohm's law Measure and calculate the equivalent resistance of series and parallel circuits. Measure and calculate the voltage distribution in series and parallel circuits Measure and calculate the current flow in series and parallel circuits.

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Month	Essential Question	Content	Skill	Assessment	Activities
	What is a magnetic field? What are the similarities and differences between Magnetic and gravitational fields? What is an magnetic field? What is the relationship between magnetic and electric fields? How are magnetic fields produced by electric current? How is electric current induced in a wire by a magnetic fields (Faraday's law of Induction)	The discovery of magnetic fields and their relationship to electric fields is examined from a historical perspective Magnetic fields are defined and compared to electric fields, rules for drawing magnetic fields are discussed. Electromagnetic induction and Faraday's law	Students will be able to: Draw magnetic fields lines Discuss/list the conditions needed for electric current to be produced from a magnetic field	Notebook assessment Homework review Lab reports and lab quizzes.	View videos on the historical development of magnetic/electromagnetic theory Lab-Experimentally determine how magnetic field strength varies with distance Lab- Examine the conditions needed to produce electric potential and current with a magnetic field.
			End of PHYSICS		

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CURRICULUM MAPPING - September
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What are the major principles of the molecular theory? How do intermolecular forces relate to physical properties such as boiling point and vapor pressure? What is a phase diagrams and what do the terms triple point, critical temperature, and critical pressure represent? How do crystalline and amorphous solid compare? What effects solubility? What are electrolytes? How are molarity, molality, % composition and mol fraction calculated? What are colligative properties and how Are related problems solved? What are factors affecting and properties of solutions, suspensions and colloids?	***AP REVIEW UNIT VI: Solids and Liquids*** Kinetic Molecular Theory; Phase diagrams for one component systems; Changes of state Structure of solids Liquids and solids form the Kinetic-molecular viewpoint Phase diagrams of one-component systems Changes of state, Critical points Triple points Structure of solids; lattice energies ***AP REVIEW UNIT VII: Solutions and Their Properties*** Properties of solutions; Factors affecting solubility; Concentration; Colligative properties. Types of solutions Raoult's law Osmosis Non-ideal behavior (qualitative aspects)	State and discuss the major tenants of the kinetic-molecular theory. Apply the kinetic-molecular theory to liquids and solids, as well as gases. Discuss intermolecular forces and relate them to physical properties such as boiling point and vapor pressure. Interpret heating curves as to melting point, boiling point, and specific heat. Interpret phase diagrams and correctly define terms such as triple point, critical temperature, and critical pressure. Discuss the phenomena of boiling, and be able to relate it to pressure. Distinguish between crystalline and amorphous solids. Define solution vocabulary. Discuss the effect that physical conditions have on solubility. Use the concepts of intermolecular forces in discussing the dissolving process and heat of solution. Separate compounds into electrolytes and non-electrolytes; separate electrolytes into ionic salts, acids, bases, acid anhydrides, and basic anhydrides. Solve problems involving molarity, molality, % composition, and mole fraction; to be able to convert between concentration designations. List the colligative properties and solve problems involving depression of freezing point, elevation of boiling point, lowering of vapor pressure, and increasing of osmotic pressure. Distinguish between an ideal and a non-ideal solution. Explain Brownian movement and the Tyndall Effect.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	Lab: **SOLIDS & LIQUIDS** **Power Points Notes** **Overhead notes** **Board Notes** **Homework**

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CURRICULUM MAPPING - October
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What fundamental skills are required for the study of chemistry? How do chemists usually solve mathematical problems? What are proper laboratory procedures? What are the parts of the atom? What are the difference between the past and present models of the atom? What principles dictate the configuration of the atom? What is the basis for the periodic law and how does it apply to periodic trends?	***AP REVIEW UNIT I: Chemical Fundamentals*** Significant Figures Measurement Metric Relationships Scientific Notation Dimensional Analysis Graphing Lab Safety Percent Error Lab Techniques ***AP REVIEW UNIT II: Atomic Structure and The Periodic Table*** Periodicity Modern atomic theory Atomic numbers Mass numbers Isotopes Energy levels, Quantum numbers Atomic orbitals. Evidence for the atomic theory Atomic mass Periodic relationships, Atomic radii, Ionization energies, Electron affinities, oxidation states Chemical reactivity Products of chemical reactions Relationships in the periodic table: Alkali metals Alkaline earth metals,	Define terms such as matter, energy, element, compound, mixture, solution. Work comfortably with the metric system Work problems using dimensional analysis. Understand and work with the proper number of significant figures. Apply knowledge of significant figures to laboratory work. Correctly use an analytical balance, a vacuum flask, and Buchner funnel. Know the name and application of the common laboratory equipment used in this course. Identify the proper safety rules and procedures to be used in experimental situations. Name the major subatomic particles in an atom. List the types of radioactive emissions. Discuss the Bohr model of the atom, and compare it to the quantum mechanical model of the atom. Discuss the major differences in the classical mechanical model and the quantum mechanical model. Work problems involving quantum numbers and energies of electron transitions. Define and discuss the following terms or concepts: Heisenberg Uncertainty Principle, Pauli Exclusion Principle, wave-particle duality of matter, Wave function of electrons (Y), radial probability, density, orbitals, aufbau process, and Hund's rule. Know the shapes of the s, p, and d orbitals. Understand the basis for the periodic law, and apply it to periodic trends such as atomic radii, ionization energy, electron affinity, melting point, oxidation states, and electronegativity.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	Lab: Melting Point of an Organic Compound. Qualitative Analysis: Anions. Qualitative Analysis: Cations. Lab: ATOMIC THEORY: Lab: PERIODICITY:

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CURRICULUM MAPPING - November
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What are Lewis structures? How do electronegativy trends help to predict bond type? How does VESPR theory help to predict molecular geometry? What are physical and chemical properties of substance using intra and intermolecular bonding?	***AP REVIEW UNIT III: Chemical Bonding*** Binding forces (ionic, covalent, metallic, network covalent, and Van der Waals) Relationships to states, structure and properties of matter; polarity of bonds; Electro negativities; Molecular models; Lewis structures; Valence Bond theory Hybridization Resonance, sigma and pi bonds; VSEPR; Molecular Orbital theory. Polarity of bonds, Geometry of molecules Ions, Structural isomerism of simple organic molecules and coordination complexes, dipole moments of molecules, relation of properties to structure	Draw Lewis structures for the common atoms, ions, and molecules. Use periodic trends of electronegativity to predict bond type. Distinguish between polar and non-polar molecules. Use electronegativity values and bonding concepts to determine oxidation states on atoms. Draw resonance structures and assign formal charges. Use the VSEPR model to predict molecular geometry. Use the hybridization theory to predict molecular geometry. Explain physical and chemical properties of substance using intra and intermolecular bonding. Draw and describe isomerism in organic and coordination complexes. .	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	generate graphs from experimental data Lab: Uncertainty Lab: Density of Liquid or Solid Demo: How to make a salad (heterogeneous) and iced tea (homogeneous) Soil vs. Salad vs. Solution compare and contrast Using MSDS labels to identify different chemical compounds and elements Demo: m & m mixtures (homogeneous/heterogeneous) Demo: Flirtation of sand and water

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CURRICULUM MAPPING - December
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
How are Chemical formulas written as word equations? How are limiting and excess reactants calculated? What is the difference between a state function and a path function? How is Hess' law used to solve entropy, enthalpy and free energy problems? What is specific heat and how is it calculated?	***AP REVIEW UNIT IV: Chemical Compounds,*** *Reactions and Stoichiometry* Quantities of materials reacted or produced in chemical reactions; mole concept empirical formulas; write formulas Name various inorganic compounds Acid-base reactions; concepts of Arrhenius, Brönsted-Lowry, and Lewis; coordination complexes; amphoterism Precipitation reactions Oxidation-reduction reactions Oxidation number Ionic and molecular species present in chemical systems: net ionic equations Balancing of equations including those for redox reactions Mass and volume relations with emphasis on the mole concept, including empirical formulas and limiting reactants ***AP REVIEW AND NEW UNIT V: Thermochemistry*** Relate the fundamental aspects of the energy changes that accompany chemical reactions.	Name the polyatomic ions, Name inorganic compounds, including acids, using the Stock system. Write formulas for inorganic compounds. Work problems involving mole concepts, molarity, percent composition, empirical formulas, and molecular formulas. Balance equations given both reactants and products Solve stoichiometric problems involving percent yield, and limiting reagents. Apply these concepts to the laboratory setting. Apply the periodic law to chemical reactivity in predicting reaction products. Discuss the activity series of the elements. Distinguish between metals and nonmetals. Classify compounds as to acids, bases, acid anhydrides, basic anhydrides, salts, and covalent molecules. Use the properties of metals and nonmetals to predict reaction products. Write chemical equations for synthesis, decomposition, single replacement, metathetical, redox, combustion, and acid-base reactions. Use the Periodic Table to predict common oxidation states. Use the Activity series of elements to predict single replacement reactions. List and define the meanings and common units for the common thermodynamic symbols. Learn the meaning of the following thermodynamic terms: enthalpy, exothermic, endothermic, system, surroundings, universe, and heat of formation, heat of reaction, calorimetry, heat, calorie, joule, standard molar enthalpy of formation, molar heat of combustion, entropy, absolute entropy, free energy. Distinguish between a state function and a path function. Define internal energy, PV work, enthalpy, entropy, and free energy. Use Hess's law to solve problems of energy, entropy, and free energy. Solve calorimetry problems involving specific heat.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	**Determination of the Formula of a Compound.** **Determination of the Percentage of Water in a Hydrate.** **Determination of Mass and Mole Relationships in a Chemical Reaction.** **Determination of Concentration by Oxidation-Reduction Titration.**

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CURRICULUM MAPPING - January
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What are the basic principles of the kinetic theory? How do intermolecular forces and relate to physical properties such as boiling point and vapor pressure? What are the laws that explain the behavior of gases and how are they used in calculations? What are the factors that influence the rate of a chemical reaction? How do zero, first, and second order reactions compare and contrast in terms of the plot needed to give a straight line, the relationship of the rate constant to the slope of the straight line, and the half-life of the reaction. What affects both the rate and the rate constant of the reaction. What is the role of a catalyst in the rate and mechanism of a reaction;	***AP REVIEW UNIT VI:*** *Gases* Laws and models that describe the properties and behaviors of gases; Kinetic Molecular Theory Laws of ideal gases Equation of state for an ideal gas Partial pressures Kinetic-molecular theory Ideal gas laws Avogadro's hypothesis The mole concept Dependence of kinetic energy of molecules on temperature Deviations from ideal gas laws ***AP NEW UNIT VIII: Kinetics*** Measure, alter, and predict the rates of a chemical reaction. Concept of rate of reaction Use of differential rate laws to determine order of reaction and rate constant from experimental data Effect of temperature change on rates Energy of activation; the role of catalysts The relationship between the rate-determining step and a mechanism	State and discuss the major tenants of the kinetic-molecular theory. Apply the kinetic-molecular theory to liquids and solids, as well as gases. Discuss intermolecular forces and relate them to physical properties such as boiling point and vapor pressure. Work problems using Dalton's Law. the Ideal Gas Law, and van der Waal's equation. State and discuss the major tenants of the kinetic-molecular theory. Apply the kinetic-molecular theory to gases. Discuss the methods and units for measuring pressure; convert between units. Work problems using: Charles' law, Boyle's law, Gay-Lussac's Law, Avogadro's Law, Dalton's Law, the Ideal Gas Law, and van der Waal's equation. List the factors that influence the rate of a chemical reaction. Use experimental data to determine the rate law, determine the order of the reaction, and to define proper units for the constant. Compare and contrast zero, first, and second order reactions in terms of the plot needed to give a straight line, the relationship of the rate constant to the slope of the straight line, and the half-life of the reaction. Use experimental data to postulate a reaction mechanism. Interpret how changing the conditions of the reaction (i.e. temperature, pressure, concentration, and addition of a catalyst) affects both the rate and the rate constant of the reaction. Discuss the role of a catalyst in the rate and mechanism of a reaction; distinguish between a homogeneous and a heterogeneous catalyst. Interpret data from a first order reaction to determine its half-life.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	**Labs** **Molar Volume of a Gas** **Molar Mass Determination via Vapor Density** **Determination of the Rate of a Chemical Reaction and its Order**

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CURRICULUM MAPPING - February
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What are the characteristics of chemical equilibrium? What is the meaning of equilibrium constant and quotient (Q) How does Le Chatelier's Principle predict the direction a system in equilibrium will shift in order to re-establish equilibrium? . What effect does a catalyst will not have on the equilibrium constant rule? What is the difference between a state function and a path function? What are some common thermodynamic symbols? What causes spontaneity in a reaction? What is the relationship between free energy change and equilibrium constants?	***AP NEW UNIT IX:*** Chemical Equilibrium; Le Chatelier's principle; Equilibrium constant. Concept of dynamic equilibrium, physical and chemical; Quantitative treatment Equilibrium constants for gaseous reactions: Kp, Kc ***AP NEW UNIT X: Thermodynamics*** State functions; First Law; Second Law; Third Law; relationship of change in free energy to equilibrium constants. Change in enthalpy; heat of formation; heat of reaction; Hess's law; heats of vaporization and fusion; calorimetry Second law: entropy; free energy of formation; free energy of reaction; dependence of change in free energy on enthalpy and entropy changes Relationship of change in free energy to equilibrium constants and electrode potentials	Describe the meaning of physical and chemical equilibrium, and give real life examples of each. Write the law of mass action for any system at equilibrium. Understand the meaning of equilibrium constant and reaction quotient (Q). Interpret the position of equilibrium from the size of the equilibrium constant. Use Le Chatelier's Principle to predict the direction a system in equilibrium will shift in order to re-establish equilibrium. Know that temperature, pressure, and concentration will shift the position of equilibrium. Understand that a catalyst will not have an effect of the equilibrium constant. rule. List and define the meanings and common units for the common thermodynamic symbols. Learn the meaning of the following thermodynamic terms: enthalpy, exothermic, endothermic, system, surroundings, universe, and heat of formation, heat of reaction, calorimetry, heat, calorie, joule, standard molar enthalpy of formation, molar heat of combustion, entropy, absolute entropy, free energy. Distinguish between a state function and a path function. Define internal energy, PV work, enthalpy, entropy, and free energy. Use Hess's law to solve problems of energy, entropy, and free energy. Define the terms exothermic & endothermic. Determine the spontaneity of a reaction. Discuss the laws of thermodynamics (in order). Understand the relationship between free energy change and equilibrium constants.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	Determination of the Equilibrium Constant for a Chemical Reaction**.**

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CURRICULUM MAPPING - March
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
How is the the half-reaction method to balance redox equations ? How is electrolytic cell distinguished from a voltaic cell in terms of function, direction and ΔG. How is Faraday's law used in solving problems? How are reaction products predicted for both electrolytic and voltaic cells? How do you name and write formulas for coordination complexes?	***AP NEW UNIT XI: Electrochemistry*** Oxidation-reduction reactions; electrolytic and galvanic cells; Faraday's Law; standard half-cell potentials; Nernst equation; prediction of the direction of redox reactions. ***AP NEW UNIT XII: Complex Ions and Coordination Compounds*** Describe the chemical properties of some of the transition metals with an emphasis on the nomenclature of complex ions and compounds.	Use the half-reaction method to balance redox equations. Define electrochemical terms: redox, anode, anion, cathode, cation, oxidizing agent, reducing agent, emf, electrode. Distinguish between an electrolytic cell and a voltaic cell in terms of function, direction and ΔG. Solve problems using Faraday's law. Predict reaction products for both electrolytic and voltaic cells. Use a table of Standard Reduction Potentials to compute cell voltages. Solve problems using the Nernst's equation. Diagram voltaic cells using proper notation. Establish the relationship between the free energy change, the cell potential, and the equilibrium constant. Discuss and give examples of dry cells, batteries and fuel cells. Define the following: central ion or atom, coordination sphere, coordination number, polydentate ligand, ligand, chelating agent, cis and trans isomers. Name and write formulas for coordination complexes.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	**Investigation of Voltaic Cells-The Nernst Equation.** **Synthesis of a Coordination Compound and its Chemical Analysis**

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CURRICULUM MAPPING - April

Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What fundamental skills are required for the study of chemistry? How do chemists usually solve mathematical problems? What are proper laboratory procedures?	***AP NEW UNIT XIII: Nuclear Chemistry*** Nuclear equations; half-lives; radioactivity; chemical applications. ***AP NEW UNIT XIV: Acids and Bases*** Acid-base reactions; concepts of Arrhenius, Bronsted-Lowry, and Lewis; amphoterism; pK; pH and pOH; common ion effect; buffers; hydrolysis. Equilibrium constants for reactions in solution Constants for acids and bases; pK; pH Common ion effect; buffers; hydrolysis	1. Work problems involving nuclear binding energy. 2. Predict nuclear stability and mode of decay using N/Z ratio. 3. Work problems involving half-life. 4. Balance nuclear equations. Distinguish between the various modern theories of acids and bases. 2. Name and write formulas for normal salts, hydrogen salts, hydroxy salts, oxysalts and acids. 3. Perform a titration and solve for the appropriate concentration. 4. Use the concept of conjugate acid-base pairs to predict reaction products. 5. Define and give examples of amphiprotic species. 6. Identify weak electrolytes. 7. Write a law of mass action for any reaction in equilibrium. 8. Know and use the water constant, K_w. 9. Define pH, pOH, pK, K_a, K_b, ionization constant, percent ionization, K_{sp}. 10. Convert from $[H_3O^+]$ or $[OH^-]$ to pH or pOH. 11. Use a pH meter to determine a titration curve and an ionization constant. 12. Pick a suitable indicator for a titration. 13. Recognize salts that undergo hydrolysis and write a reaction for the ion with water. 14. Given the concentration and amount of weak acids or bases and an appropriate titrant, calculate	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	**Labs:** **Investigation of a Buffer System.** **Determination of K_a of a Weak Acid.** **Determination of pH.**

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CURRICULUM MAPPING - May
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What fundamental skills are required for the study of chemistry? How do chemists usually solve mathematical problems? What are proper laboratory procedures?	***AP NEW UNIT XV: Solubility Product and Complex Ion Equilibrium*** Calculate the solubility product of a salt given its solubility and vice versa; predict the relative solubilities from K_{sp} values; explain the effect of pH and a common ion on the solubility of a salt. Solubility product constants and their application to precipitation ***AP NEW UNIT XVI: Organic Chemistry*** Become familiar with basic hydrocarbon chemistry, properties, and nomenclature.	Write solubility product expressions for slightly soluble compounds. 2. Solve problems involving: (a) solubility product constants from solubility; (b) molar solubility from K_{sp}; (c) concentrations of substances necessary to produce a precipitate; (d) concentrations of ions involved in simultaneous equilibrium. Define the following: cis and trans isomers, alkane, alkene, alkyne, alcohol, aldehyde, ketone, carboxylic acid, ether, ester, ammine, aromatic. 2. Name and write formulas for major functional groups. 3. Name and draw structures of basic organic compounds.	Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	**Determination of K_{sp} of a Salt Synthesis, Purification, and Analysis of Aspirin.** **Preparation of an Ester.**

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CURRICULUM MAPPING - June
Chemistry Department AP Chemistry

Essential Questions	Content	Skills	Assessment	Activities
What fundamental skills are required for the study of chemistry? How do chemists usually solve mathematical problems? What are proper laboratory procedures?	**Students will work on remaining lab assignments while synthesizing the course material and preparing for course final.**		Tests, Quizzes, Homework, Written Lab Reports, Class Work, Lab Practical	generate graphs from experimental data

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Chemistry Academic Curriculm

Course Code: SCI—3400 Chemistry Academic
Grade Level: 10th & 11th Grades

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

Developed by Ahmed Khan & the ACHS Curriculum Committee
Reviewed by Science Supervisor.

BOARD OF EDUCATION

ADOPTION DATE: August 2018

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BOARD OF
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ACKNOWLEDGEMENTS

Administrative Team

Ms. Lina Gil — Principal (2016)
Dr. Sheree Alexander — Vice-Principal (2016)
Mr. Stephen Brown — Vice-Principal (1998)
Mr. Jason Grimes — Vice-Principal (2017)
Mr. Kendall Williams — Vice-Principal (2018)

Science Department

Mrs. Dianna Arndt — Teacher of Secondary Earth & Space Science (2017)
Mrs. Agnes Arsenis — Teacher of Secondary Physical Science (1991)
Mr. Ephram Bailey — Teacher of Secondary Biological Science (2009)
Mrs. Regina Banner — Teacher of Secondary Biological Science (2001)
CWO Christopher Brown — Teacher of Military Science (2013)
Mrs. Mia Campo — Teacher of Special Education (Students with Disabilities)(Secondary (2007)
Mr. Mark Chando — Teacher of Secondary Biological Science (2004) Elementary Teacher of Secondary Science (1992)
Mr. Bjorn Christiano — Teacher of Secondary Biological Science (2007)
Mr. Kevin Corcoran — Teacher of Secondary Biological Science (2001)
Ms. Riana Cordoba — Teacher of Special Education (Students with Disabilities)(Secondary) (2016) / Special Ed Teacher of Secondary Biological Science (2015)
Dr. John Edmunds, D.C. — Teacher of Secondary Biological Science (1998)
Mrs. Barbara Hamill — Teacher of Secondary Physical Science (2001)
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Mrs. Courtney Keim — Teacher of Secondary Physical Science (2006)
Mr. Robert Lamoreux — Teacher of Secondary Comprehensive Science (2002)
Mr. Frank Manzo — Teacher of Secondary Biological Science (1992)
Mr. Steve Nagiewicz — Teacher of Secondary Earth Science (2007)
Mr. Buddy O'Brien — Teacher of Secondary Biological Science (2001)
Mr. Christopher Oves — Teacher of Special Education (Handicapped)(Secondary) (2002)
Mr. William Wineland — Teacher of Special Education (Students With Disabilities)(Secondary) (2010)

QSAC STATEMENT OF ASSURANCE (SOA)

August 21, 2017
TO: District Superintendents
District Curriculum Directors/Supervisors
District Board of Education Presidents
FROM: Pamela J. Garozzo PJG Director, County Office Administrative Unit and
QSAC SUBJECT: QSAC Statement of Assurance (SOA)
Instruction and Program #3 – Curriculum Alignment and Adoption Requirements

The purpose of this document is to clarify the requirements for board-adopted, aligned curricula, so that you can provide an accurate response to the QSAC Statement of Assurance (SOA), Instruction and Program indicator #3. As required by N.J.A.C. 6A:8-3.1, all curricula must include:

- Interdisciplinary connections through the K-12 curriculum;
- Integration of 21st century themes and skills; and
- Supportive curricula and instructional tools for helping students acquire required knowledge and skills.

These tools include at a minimum:

- Pacing guide
- List of core instructional materials, including various levels of texts at each grade level
- Benchmark assessments
- Modifications for special education students, English language learners, students at risk of school failure and gifted students

Further, all curricula must be aligned to current academic standards. As you know, the New Jersey State Board of Education has adopted academic standards in Visual and Performing Arts, Comprehensive Health and Physical Education, English Language Arts, Mathematics, Science, Social Studies, World Languages, Technology and 21st Century Life and Careers

PROPOSED NJQSAC DISTRICT PERFORMANCE
REVIEW

Since September 2017, science in kindergarten through grade five has been based on the NJSLS-S.

The New Jersey Student Learning Standards for Science (NJSLS-S) are currently the academic target in grades 6-12. The implementation of the standards is only one milestone in a long process of transforming teaching, learning, and assessment necessary for our students to meet the new challenges.

(**Effective July 1, 2018**)

11. Science curriculum and instruction are aligned to the NJSLS in accordance with the Department's curriculum implementation timeline and include the following: (N.J.A.C. 6A:8)

a. Curriculum designed and implemented to meet grade level expectations/graduation requirements;

b. Integrated accommodations and modifications for students with IEPs, 504s, ELLs, and gifted and talented students;

c. Assessments- including benchmarks, formative, summative and alternative assessments;

d. List of core instructional and supplemental materials, including various levels of texts at each grade level;

e. Pacing guide;

f. Interdisciplinary connections;

g. Integration of 21st century skills;

h. Integration of the Technology standard;

i. Integration of the 21st Century Life and Career standards/career counseling.

Ahmed Khan,
M.A.I.T.
Teacher of Secondary Physical Science (1992)
Atlantic City High School

Steven Nagiewicz
Teacher of Secondary Earth & Space Science (2008)
Atlantic City High School

INTRODUCTIO N

This document is part of a family of resources that are designed to support the transition to the new science standards. Each tool is designed for a specific purpose but they are all grounded the Framework for K-12 Science Education (2012) and the NJSLS-S. The other documents in the family of tools include:

- *Science Instruction Companion to the Danielson Framework* provides science specific indicators for evaluating science instruction;
- *NGSS Lesson Screener* provides criteria for an informal review (no scoring) of a lesson or short unit's coherence with the NJSLS-S;
- *EQuIP Rubric for Lessons and Units: Science* provides detailed criteria to measure the degree to which lessons and units are designed for the NJSLS-S;
- *Primary Evaluation of Essential Criteria (PEEC)* provides criteria to evaluate curriculum materials such as science kits, textbook series, or online programs.

Table 1: Criteria for an Effective Science Program

A. **All Standards, All Students**: The science program ensures that ALL students are provided appropriate learning opportunities for ALL of the standards. This includes but is not limited to, students with disabilities, economically disadvantages, English Language Learners, and students who have been identified as gifted.
B. **Explaining Phenomena or Designing Solutions**: The units focus on supporting students to make sense of engaging and authentic phenomena or design solutions to real-world problem.
C. **Three Dimensional**: The units help students develop and use multiple grade- appropriate elements of the science and engineering practices (SEP), disciplinary core ideas (DCI), and crosscutting concepts (CCC), which are deliberately selected to aid student sense-making of phenomena or designing of solutions.
D. **Integrating the Three Dimensions for Instruction and Assessment**: The units require student performances that integrate elements of the SEPs, CCCs, and DCIs to make sense of phenomena or design solutions to problems, and the learning tasks elicit student artifacts that show direct, observable evidence of three-dimensional learning.
E. **Relevance and Authenticity**: The units motivate student sense-making or problem- solving by taking advantage of student questions and prior experiences in the context of the students' home, neighborhood, and community as appropriate.
F. **Student Ideas**: The units provide opportunities for students to express, clarify, justify, interpret, and represent their ideas (i.e., making thinking visible) and to respond to peer and teacher feedback.
G. **Building on Students' Prior Knowledge**: The units identify and build on students' prior learning in all three dimensions in a way that is explicit to both the teacher and the students.

OVERVIEW OF CHEMISTRY

Chemistry introduces the student to the study of matter, its composition and structure, and the changes it may undergo. A study of the structure of the atom combined with the periodic law leads to an understanding of the organization of the elements in the periodic table. This knowledge of the atom and the organization of the elements is used to develop concepts of ionic, covalent and metallic bonding among atoms as well as to write formulas for compounds and equations to represent chemical reactions. Phases of matter will be studied and will include an introduction to gas laws, water, aqueous systems and solutions. The course will also incorporate the study of thermochemistry including the concept of heat flow and the relationship between heat and temperature and rates of reaction. Students will be introduced to acids and bases, oxidation and reduction reactions and be able distinguish a fission reaction from a fusion reaction

This course is developed for the student who wishes to have a basic understanding of chemistry as an integral part of the study of nature and as a preparation for advanced science courses. Additionally, an understanding of the scientific process, scientific method, and rational thinking skills is essential for students to sort and evaluate incoming information.

OVERVIEW OF UNITS Chemistry Model Units

Unit 1: Structure and Properties of Matter **Instructional Days: 30**
In this unit of study, students use investigations, simulations, and models to makes sense of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Students are expected to communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. The crosscutting concepts of *structure and function*, *patterns, energy and matter*, and *stability and change* are called out as the framework for understanding the disciplinary core ideas. Students use *developing and using models, planning and conducting investigations, using mathematical thinking, and constructing explanations and designing solutions.* Students are also expected to use the science and engineering practices to demonstrate proficiency with the core ideas.
This unit is based on HS-PS1-1, HS-PS1-2, HS-PS1-3, HS-PS2-6, HS-ETS1-3, and HS-ETS1-4.

Unit 2: The Chemistry of Abiotic Systems1 **Instructional Days: 20**
In this unit of study, students *develop and use models, plan and carry out investigations, analyze and interpret data, and engage in argument from evidence to make sense of energy* as a quantitative property of a system—a property that depends on the motion and interactions of matter and radiation within that system. They will also use the findings of investigations to provide a mechanistic explanation for the core idea that total change of energy in any system is always equal to the total energy transferred into or out of the system. Additionally, students develop an understanding that energy, at

both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy associated with the configurations (relative positions) of particles.

Students apply their understanding of energy to explain the role that water plays in affecting weather. Students examine the ways that human activities cause feedback that create changes to other systems. Students are expected to demonstrate proficiency in *developing and using models, planning and carrying out investigations, analyzing and interpreting data, engaging in argument from evidence,* and using these practices to demonstrate understanding of core ideas.

Students also develop possible solutions for major global problems. They begin by breaking these problems into smaller problems that can be tackled with engineering methods. To evaluate potential solutions, students are expected not only to consider a wide range of criteria, but also to recognize that criteria need to be prioritized.
This unit is based on HS-PS3-4, HS-ESS2-5, HS-ESS3-2, and HS-ETS1-3.

Unit 2B: Energy of Chemical Systems[1] **Instructional Days: 20**
Unit 2B is use in a chemistry course when **Unit 2: The Chemistry of Abiotic Systems** is taught in the **Capstone Science Course**. In Energy of Chemical Systems, students will understand energy as a quantitative property of a system—a property that depends on the motion and interactions of matter and radiation within that system. They will also understand that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy, at both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy associated with the configurations (relative positions) of particles.

Students understand the role that water plays in affecting weather. Students can examine the ways that human activities cause feedback that create changes to other systems. Students are expected to demonstrate proficiency *in developing and using models, planning and carrying out investigations, analyzing and interpreting data, engaging in argument from evidence*, and using these practices to demonstrate understanding of core ideas.
This unit is based on HS-PS3-4.

FOOTNOTE: [1] This unit can be taught in either Chemistry or as part of the Capstone Science Course. If this unit is transferred to the Capstone Course, an abbreviated unit on Energy, based on HS—PS3-4, must be provided in its place.

Unit 3: Bonding and Chemical Reactions **Instructional Days: 30**
In this unit of study, students develop and using models, plan and conduct investigations, use mathematical thinking, and construct explanations and design solutions as they develop an understanding of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students also apply an understanding of the process of optimization and engineering design to chemical reaction systems. The crosscutting concepts of patterns, energy and matter, and stability and change are the organizing concepts for these disciplinary core ideas. Students are expected to

demonstrate proficiency in developing and using models, planning and conducting investigations, using mathematical thinking, and constructing explanations and designing solutions.
This unit is based on HS-PS1-7, HS-PS1-4, HS-PS1-5, HS-PS1-6, and HS-ETS1-2.

Unit 4: Matter and Energy in Living Systems Instructional Days: 20
In this unit of study, students construct explanations for the role of energy in the cycling of matter in organisms. They apply mathematical concepts to develop evidence to support explanations of the interactions of photosynthesis and cellular respiration and develop models to communicate these explanations. The crosscutting concept of matter and energy provides students with insights into the structures and processes of organisms.

Students are expected to develop and use models, plan and conduct investigations, use mathematical thinking, and construct explanations and design solutions as they demonstrate proficiency with the disciplinary core ideas.
This unit is based on HS-LS1-7 and HS-LS1-6.

Unit 5: Nuclear Chemistry[2] Instructional Days: 30
In this unit of study, energy and matter are studied further by investigating the processes of nuclear fusion and fission that govern the formation, evolution, and workings of the solar system in the universe. Some concepts studied are fundamental to science and demonstrate *scale, proportion, and quantity,* such as understanding how the matter of the world formed during the Big Bang and within the cores of stars over the cycle of their lives.

In addition, an important aspect of Earth and space sciences involves understanding the concept of stability and change while making inferences about events in Earth’s history based on a data record that is increasingly incomplete the farther one goes back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record.

The crosscutting concepts of energy and matter; scale, proportion, and quantity; and stability and change are called out as organizing concepts for this unit. Students are expected to demonstrate proficiency in *developing and using models; constructing explanations and designing solutions; using mathematical and computational thinking; and obtaining, evaluating, and communicating information;* and they are expected to use these practices to demonstrate understanding of the core ideas.
This unit is based on HS-PS1-8, HS-ESS1-3, HS-ESS1-1, HS-ESS1-2, and HS-ESS1-6

FOOTNOTE: [2] This unit can be taught in either Chemistry or as part of the Capstone Science Course.

Unit 6: Human Impact: The Chemistry of Sustainability[3] Instructional Days: 30
In this unit of study, students use cause and effect to develop models and explanations for the ways that feedbacks among different Earth systems control the appearance of Earth’s surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth’s surface (e.g., volcanism and mountain building), and the sun-driven surface systems that tear down the land through weathering and erosion. Students begin to examine the ways that human activities cause feedbacks that create changes to other systems. Students understand the system interactions that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students model

the flow of energy and matter between different components of the weather system and how this affects chemical cycles such as the carbon cycle. Engineering and technology figure prominently here, as students use mathematical thinking and the analysis of geoscience data to examine and construct solutions to the many challenges facing long-term human sustainability on Earth. Here students will use these geoscience data to explain climate change over a wide range of timescales, including over one to ten years: large volcanic eruption, ocean circulation; ten to hundreds of years: changes in human activity, ocean circulation, solar output; tens of thousands to hundreds of thousands of years: changes to Earth's orbit and the orientation of its axis; and tens of millions to hundreds of millions of years: long-term changes in atmospheric composition).
This unit is based on HS-ESS2-4, HS-ESS2-6, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, and HS-ETS1-

4. FOOTNOTE: [3] This unit can be taught in either Chemistry or as part of the Capstone Science

Course.

Note: The number of instructional days is an estimate based on the information available at this time. 1 day equals approximately 42 minutes of seat time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.

Unit 1: Structure and Properties of Matter

Instructional Days: 30

This unit is based on HS-PS1-1, HS- PS1-2, HS-PS1-3, HS-PS2-6, HS- ETS1-3, and HS-ETS1-4.

UNIT 1 Summary Structure and Properties of Matter **Instructional Days: 30**

How can the substructures of atoms explain the observable properties of substances?

In this unit of study, students use investigations, simulations, and models to makes sense of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Students are expected to communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. The crosscutting concepts of *structure and function*, *patterns*, *energy and matter*, and *stability and change* are called out as the framework for understanding the disciplinary core ideas. Students use *developing and using models*, *planning and conducting investigations*, *using mathematical thinking*, and *constructing explanations and designing solutions*. Students are also expected to use the science and engineering practices to demonstrate proficiency with the core ideas.

UNIT 1 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.

Textbook

Chemistry, Antony Wilbraham, (PEARSON-PRENTICE HALL: 2008)

Core Instructional Materials

- Laptop Cart
- Microsoft office
- CD-Rom Chemistry
- Internet resources
- Virtual Labs

UNIT 1 Student Learning

INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS &

Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. *[Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of*

metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.] **(HS-PS1-1)**
Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. *[Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.]* [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.*]* **(HS-PS1-2)**
Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. *[Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite).* Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [*Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.*] **(HS-PS1-3)**
Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* *[Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]* **(HS-PS2-6)**
Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. (HS-ETS1-3)
Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. (HS-ETS1-4)

UNIT 1 Quick Links

Part A: *How can a periodic table tell me about the subatomic structure of a substance?* **CONNECTION TO LESSON PLAN HERE**	
Concepts **INSERT CHAPTER KEY CONCEPTS FROM**	**Formative Assessment** **INSERT CHAPTER OBJECTIVE FROM**
• Different patterns may be observed at each of the scales at which a system is studied, and these patterns can provide evidence for causality in explanations of phenomena. • Each atom has a charged substructure. • An atom's nucleus is made of protons and neutrons and is surrounded by electrons. • The periodic table orders elements horizontally by number of protons in the nucleus of each element's atoms and places elements with similar chemical properties in columns. • The repeating patterns of this table reflect patterns of outer electron states. • Patterns of electrons in the outermost energy level of atoms can provide evidence for the relative properties of elements at different scales. • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	*Students who understand the concepts are able to:* • Use the periodic table as a model to provide evidence for relative properties of elements at different scales based on the patterns of electrons in the outermost energy level of atoms in main group elements. • Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms in main group elements.

Part B: *How can I use the periodic table to predict if I need to duck before mixing two elements?*

Concepts	Formative Assessment
• The periodic table orders elements horizontally by number of protons in the nucleus of each element's atoms and places elements with similar chemical properties in columns. • The repeating patterns of the periodic table reflect patterns of outer electron states. • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. • Different patterns may be observed at each of the scales at which a system is studied, and these patterns can provide evidence for causality in explanations of phenomena.	*Students who understand the concepts are able to:* • Use valid and reliable evidence (obtained from students' own investigations, models, theories, simulations, and peer review) showing the outermost electron states of atoms, trends in the periodic table, and patterns of chemical properties to construct and revise an explanation for the outcome of a simple chemical reaction. • Use the assumption that theories and laws that describe the outcome of simple chemical reactions operate today as they did in the past and will continue to do so in the future. • Observe patterns in the outermost electron states of atoms, trends in the periodic table, and chemical properties. • Use the conservation of atoms and the chemical properties of the elements involved to describe and predict the outcome of a chemical reaction.

Part C: *How can I use the properties of something (in bulk quantities) to predict what is happening with the subatomic particles?*	
Concepts	**Formative Assessment**
• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	*Students who understand the concepts are able to:* • Plan and conduct an investigation individually and collaboratively to produce data that can serve as the basis for evidence for comparing the structure of substances at the bulk scale to infer the strength of electrical forces between particles. In the investigation design, decide on types, how much, and accuracy of data needed to produce reliable measurements;

	consider limitations on the precision of the data (e.g., number of trials, cost, risk, time); and refine the design accordingly. • Use patterns in the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Part D: I want to do the right thing, what is the greener choice for *grocery bags (paper or plastic/reusable vs. disposable); cold drink containers (plastic, glass, or aluminum); or hot drink containers (paper, Styrofoam, or ceramic)? [Clarification: Students should have the opportunity to select the product and use the Life Cycle Analysis (LCA) to make an evidence-based claim.]*	
Concepts	**Formative Assessment**
• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, aesthetics, and to consider social, cultural, and environmental impacts. • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. • Models (e.g., physical, mathematical, computer models) can be used to simulate why the molecular-level structure is important in the functioning of designed materials.	*Students who understand the concepts are able to:* • Communicate scientific and technical information about why the molecular - level structure is important in the functioning of designed materials. • Evaluate a solution to a complex real-world problem based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoffs considerations to determine why the molecular level structure is important in the functioning of designed materials. • Use mathematical models and/or computer simulations to show why the molecular level structure is important in the functioning of designed materials. • Communicate scientific and technical information about the attractive and repulsive forces that determine the functioning of the material. • Use mathematical models and/or computer simulations to show the attractive and repulsive forces that determine the functioning of the material.

	• Examine in detail the properties of designed materials, the structure of the components of designed materials, and the connections of the components to reveal the function. • Use models (e.g., physical, mathematical, computer models) to simulate systems of designed materials and interactions--including energy, matter, and information flows--within and between designed materials at different scales.

UNIT 1 What It Looks Like in the Classroom
In order to understand how the periodic table can be used as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms, students must first understand the idea that atoms have a charged substructure consisting of a nucleus that is composed of protons and neutrons surrounded by electrons. Students should use a variety of models to understand the structure of an atom. Examples may include computer simulations, drawings, and kits. Students can create models of atoms by calculating protons, neutrons, and electrons in any given atom, isotope, or ion. In order to understand the predictive power of the periodic table, students should write electron configurations for main group elements, paying attention to patterns of electrons in the outermost energy level. Students should annotate the periodic table to determine its arrangement horizontally by number of protons in the atom's nucleus and its vertical arrangement by the placement of elements with similar chemical properties in columns. Students should also be able to translate information about patterns in the periodic table into words that describe the importance of the outermost electrons in atoms. • Students use the ideas of attraction and repulsion (i.e., charges—cations/anions) at the atomic scale to explain the structure of matter, such as in ion formation, and to explain the properties of matter such as density, luster, melting point, boiling point, etc. • Students also use the ideas of attraction and repulsion (charges—cations/anions) at the atomic scale to explain transformations of matter—for example, reaction with oxygen, reactivity of metals, types of bonds formed, and number of bonds formed. Students will explain bonding through the patterns in outermost electrons, periodic trends, and chemical properties.

To explain the outcomes of chemical reactions using the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties, students should use investigations, simulations, and models of chemical reactions to prove that atoms are conserved. For example, students might observe simple reactions in a closed system and measure the mass before and after the reaction as well as count atoms in reactants and products in chemical formulas. Students should also construct chemical formulas involving main group elements in order to model that atoms are conserved in chemical reactions (the Law of Conservation of Mass). Students need to describe and predict simple chemical reactions, including combustion, involving main group elements. Students should use units when modeling the outcome of chemical reactions. When reporting quantities, students should choose a level of accuracy appropriate to limitations on measurement.

Students should also be able to write a rigorous explanation of the outcome of simple chemical reactions, using data from their own investigations, models, theories, and simulations. They should strengthen their explanations by drawing and citing evidence from informational text.

In order to address how the substructure of substances at the bulk scale infers the strength of electrical forces between particles, emphasis should be placed on the importance of outermost electrons in bulk physical properties, bonding, and stability. Students must realize that valence electrons are important.

Students should plan and conduct investigations to show that structure and interactions of matter at the bulk amount, and accuracy of data required producing reliable information and considering limitations on the precision of the data.

Students should also plan and conduct investigations using attraction and repulsion (charges—cations/anions) at the atomic scale to explain the structure of matter at the bulk scale. For example, students could investigate how the strength of forces between particles is dependent on particle type (ions, atoms, molecules, networked materials [allotropes]). Students should examine crystal structures and amorphous structures.

Students should also plan and conduct investigations using attraction and repulsion (charges—cations/anions) at the atomic scale to explain the properties of matter at the bulk scale—for example, investigating melting point, boiling point, vapor pressure, and surface tension. Students might also plan and conduct an investigation using attraction and repulsion (charges—cations/anions) at the atomic scale to explain transformations of matter at the bulk scale—for example, collecting data to create cooling and heating curves.

Students might also conduct research projects to compare the structure of substances at the bulk scale and use this research to infer the strength of electrical forces between particles. Information should be gathered from multiple reliable sources and used to support claims. Any data reported should include appropriate units while considering limitations on measurements.

As students consider communicating scientific and technical information about why the molecular-level structure is important in the functioning of designed materials, the focus should be on attractive and repulsive forces. Students might research information about Life Cycle Analysis (LCA), which examines every part of the production, use, and final disposal of a product. LCA requires that students examine the inputs (raw materials and energy) required to manufacture products, as well as the outputs (atmospheric emissions, waterborne wastes, solid wastes, coproducts, and other resources). This allows them to make connections between molecular-level structure and product functionality. Students should evaluate the LCA process and communicate a solution to a real-world problem, such as the environmental impact of different types of grocery bags (paper or plastic/reusable vs. disposable), cold drink containers (plastic, glass, or aluminum), or hot drink containers (paper, Styrofoam, or ceramic). They should base their solution to their chosen real-world problem on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Students should then use technology to present a life-cycle-stage model that considers the LCA and typical inputs and outputs measured for their real-world problem. Students need to consider the properties of various materials (e.g. Molar mass, solubility, and bonding) to decide what materials to use for what purposes, inputs and outputs measured for their real-world problem. Students must consider the properties of various materials (e.g. Molar mass, solubility, bonding) to decide which materials to use for which purposes. When students have properties appropriate for the final use, they will be able to consider material uses in LCAs to determine if they are environmentally appropriate. For further reference, see ChemMatters, February 2014, "It's Not Easy Being Green, Or Is It?" at www.acs.org/content/acs/en/education/resources/highschool/chemmatters.html.

Integration of Engineering

In this unit, students consider communicating scientific and technical information about why the molecular level structure is important in the functioning of designed materials. Students evaluate a solution to a complex real-world problem, such as electrically conductive materials made of metal, plastics made of organic polymers, or pharmaceuticals designed for specific biological targets, and then use a computer simulation to model the impact of that solution.

UNIT 1 Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum.

English Language Arts/Literacy

- Translate information from the periodic table about the patterns of electrons in the outermost energy level of atoms into words that describe the relative properties of elements.
- Write an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties of elements using well-chosen, relevant, and sufficient facts; extended definitions; and concrete details from students' own investigations, models, theories, simulations, and peer review.
- Develop and strengthen explanations for the outcome of a simple chemical reaction by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties of elements.
- Draw evidence from informational texts about the outermost electron states of atoms, trends in the periodic table, and patterns of chemical properties of elements to construct a rigorous explanation of the outcome of a simple chemical reaction.
- Cite specific textual evidence comparing the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
  - Conduct short as well as more sustained research projects to compare the structure of substances at the bulk scale and use this research to infer the strength of electrical forces between particles.
  - Gather applicable information from multiple reliable sources to support the claim that electrical forces between particles can be used to explain the structure of substances at the bulk scale.
    - Develop evidence comparing the structure of substances at the bulk scale and the strength of electrical forces between particles.

Mathematics

- Determine a level of accuracy appropriate to limitations on measurement when reporting quantities representing periodic trends for main group elements based on patterns of electrons in the outermost energy level of atoms.
- Considering the outermost energy level of atoms, define appropriate quantities for descriptive modeling of periodic trends for main group elements based on patterns of electrons in outermost energy levels.

- Use units as a way to understand the outcome of a simple chemical reaction involving main group elements based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. Choose and interpret units consistently in chemical reactions.

- Determine and interpret the scale and origin in graphs and data displays representing patterns of chemical properties, outer electron states of atoms, trends in the periodic table, and patterns of chemical properties.
- Determine a level of accuracy appropriate to limitations on measurement when reporting quantities of simple chemical reactions.
- Use units as a simple way to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. Choose and interpret units comparing the structure of substances at the bulk scale to infer the strength of electrical forces between particles. Choose and interpret the scale and origin in graphs and data displays comparing the structure of substances and the bulk scale and electrical forces between particles.

  - Determine a level of accuracy appropriate to limitations on measurements of the strength of electrical forces between particles.

UNIT 1 Modifications for special education students, English language learners, students at risk of school failure and gifted students

Teacher Note: Teachers identify the modifications that they will use in the unit.

- ☐ Restructure lessons using Universal Design for Learning (UDL) principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)
- ☐ Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- ☐ Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- ☐ Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- ☐ Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- ☐ Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.

- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide English Language Learners students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 1 Research on Student Learning

Students of all ages show a wide range of beliefs about the nature and behavior or particles. They lack an appreciation of the very small size of particles; believe there must be something in the space between particles; have difficulty in appreciating the intrinsic motion of particles in solids, liquids and gases; and have problems in conceptualizing forces between particles (NSDL, 2015).

UNIT 1 Prior Learning

By the end of grade 8, students understand:

Physical science

- Substances are made from different types of atoms, which combine with one another in various ways.
- Atoms form molecules that range in size from two atoms to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others.
- In a gas, the molecules are widely spaced except when they happen to collide.
- In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

- Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, whereas others store energy.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics.
- These physical and chemical properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting point of rocks.

UNIT 1 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.

Biology

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used, for example, to form new cells.
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another.
- Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.
- Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Earth and space science

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

UNIT 1 Sample of Open Education Resources. Links to Free and Low Cost Instructional Resources

Build an Atom**:** This simulation allows students to create different illustrations of atoms and provides evidence that protons determine the identity of the element.

Periodic Table Trends**:** This is a virtual investigation of the periodic trends.

Path to Periodic Table**:** This investigation provides students with the opportunity to make sense of how and why the periodic table is organized the way that it is. Students will re-create the thought process that Dmitri Mendeleev and Julius Lothar Meyer went through to devise their early periodic tables.

Castle of Mendeleev**:** Students engage in a fantasy world that requires them to make claims, based on evidence, regarding the identity of unknown materials.

Shall We Dance? – Classifying Types of Chemical Reactions: Students identify and differentiate between four types of chemical reactions: synthesis, decomposition, single replacement and double replacement. Students also develop models for chemical reactions and identify the limitations of the models using evidence.

UNIT 1 Appendix A: NGSS and Foundations for the Unit

Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. *[Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]* **(HS-PS1-1)**

Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. *[Clarification Statement: Examples of chemical* *reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [*Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.*]* **(HS-PS1-)**

Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. *[Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite).* Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [*Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.*] **(HS-PS1-)**

Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* *[Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [*Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.*]* **(HS-PS2-6)**

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.(HS-ETS1-)

Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. (HS-ETS1-)

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)	**PS1.A: Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for

Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3) **Constructing Explanations and Designing Solutions** • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)	protons and neutrons, surrounded by electrons. (HS-PS1-1) • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (*secondary to HS-PS2-6*) **PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2) **PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary to HS-PS1-1),(secondary to HS-PS1-3)* **ESS2.D: Weather and Climate**	causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3) **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6) **Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of

Obtaining, Evaluating, and Communicating Information • Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **Using Mathematics and Computational Thinking** • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)	• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)	decisions about technology. (HS-ETS1-1) (HS-ETS1-3)

UNIT 1 Embedded English Language Arts/Literacy and Mathematics Standards
English Language Arts/Literacy **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3)

WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2),(HS-ETS1-3)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3)
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3),(HS-ETS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-3)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)
Mathematics	
MP.2	Reason abstractly and quantitatively. (HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-ETS1-3),(HS-ETS1-4)

HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3)

Unit 2: The Chemistry of Abiotic Systems

Instructional Days: 30

This unit is based on HS-PS3-4, HS- ESS2-5, HS-ESS3-2, and HS-ETS1-3.

UNIT 2 Summary The Chemistry of Abiotic Systems	Instructional Days: 30

Why are we so lucky that water has the physical properties that it does? How do ancient carbon atoms drive economic decisions in the modern world?

In this unit of study, students *develop and use models*, *plan and carry out investigations*, *analyze and interpret data*, and *engage in argument from evidence* to make sense of energy as a quantitative property of a system—a property that depends on the motion and interactions of matter and radiation within that system. They will also use the findings of investigations to provide a mechanistic explanation for the core idea that total change of energy in any system is always equal to the total energy transferred into or out of the system. Additionally, students develop an understanding that energy, at both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy associated with the configurations (relative positions) of particles.

Students apply their understanding of energy to explain the role that water plays in affecting weather. Students examine the ways that human activities cause feedback that create changes to other systems. Students are expected to demonstrate proficiency in *developing and using models*, *planning and carrying out investigations*, *analyzing and interpreting data*, *engaging in argument from evidence*, and using these practices to demonstrate understanding of core ideas.

Students also develop possible solutions for major global problems. They begin by breaking these problems into smaller problems that can be tackled with engineering methods. To evaluate potential solutions, students are expected not only to consider a wide range of criteria, but also to recognize that criteria need to be prioritized.

This unit is based on HS-PS3-4, HS-ESS2-5, HS-ESS3-2, and HS-ETS1-3.

UNIT 1 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.

Textbook

Chemistry, Antony Wilbraham, (PEARSON-PRENTICE HALL: 2008)

Core Instructional Materials

• Laptop Cart
• Microsoft office
• CD-Rom Chemistry
• Internet resources

• Virtual Labs

UNIT 2 Student Learning **INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS &**
Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). *[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]* **(HS-PS3-4)**
Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. *[Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]* **(HS-ESS2-5)**
Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* *[Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]* **(HS-ESS3-2)**
Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, **including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.** *[Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-3)**

UNIT 2 Quick Links

Unit Sequence p. 2 **What it Looks Like in the Classroom p.** **Connecting with Ela/literacy and Math p.** **Modifications p.**	**Research on Learning p.** **Prior Learning p.** **Connections to Other Courses p.**	**Sample Open Education Resources p.** **References p.** **Appendix A: NGSS and Foundations p.**

Part A: *Does thermal energy always transfer or transform in predictable ways?* **CONNECTION TO LESSON PLAN HERE**	
Concepts **INSERT CHAPTER KEY CONCEPTS FROM**	**Formative Assessment** **INSERT CHAPTER OBJECTIVE FROM**
☐ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. ☐ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. ☐ Uncontrolled systems always move toward more stable states—that is, toward a more uniform energy distribution. ☐ Although energy cannot be destroyed, it can be converted into less useful forms—for example, to thermal energy in the surrounding environment.	*Students who understand the concepts are able to:* ☐ Plan and conduct an investigation individually or collaboratively to produce data on transfer of thermal energy in a closed system that can serve as a basis for evidence of uniform energy distribution among components of a system when two components of different temperatures are combined. ☐ Use models to describe a system and define its boundaries, initial conditions, inputs, and outputs. ☐ Design an investigation to produce data on transfer of thermal energy in a closed system that can serve as a basis for evidence of uniform energy distribution among components of a system when two components of different temperatures are combined, considering types, how much, and the accuracy of data needed to produce reliable measurements. ☐ Consider the limitations of the precision of the data collected and refine the design accordingly

Part B: *What makes water's properties essential to life on our planet? or Why do we look for water on other planets? or What makes* *water so special?*

Concepts	Formative Assessment
• The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. • The functions and properties of water and water systems can be inferred from the overall structure, the way the components are shaped and used, and the molecular substructure. • These properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks.	*Students who understand the concepts are able to:* • Plan and conduct an investigation individually and collaboratively of the properties of water and its effects on Earth materials and surface processes. • Use models to describe a hydrological system and define its boundaries, initial conditions, inputs, and outputs. • Design an investigation considering the types, how much, and accuracy of data needed to produce reliable measurements. • Consider the limitations on the precision of the data collected and refine the design accordingly.

Part C: *What is the best energy source for a home? How would I meet the energy needs of the house of the future?*

Concepts	Formative Assessment
• All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. • Models can be used to simulate systems and interactions, including energy, matter, and information flows, within and between systems at different scales. • Engineers continuously modify design solutions to increase benefits while decreasing costs and risks. • Analysis of costs and benefits is a critical aspect of decisions about technology.	*Students who understand the concepts are able to:* • Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations). • Use models to evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost–benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).

• Scientific knowledge indicates what can happen in natural systems, not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. • New technologies can have deep impacts on society and the environment, including some that were not anticipated. • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. • Many decisions are made not using science alone, but instead relying on social and cultural contexts to resolve issues.	

UNIT 2 What It Looks Like in the Classroom
In this unit of study, students begin by building their understanding of the law of conservation of energy by planning and conducting investigations of thermal energy transfer. Students should investigate and describe a system focusing specifically on thermal energy transfer in a closed system. These investigations will provide opportunities for students to use models that can be made of a variety of materials, such as student-generated drawings and/or digital simulations, such as those available from PhET. These models can be used to describe a system, and define its boundaries, initial conditions, inputs, and outputs. Students should have the opportunity to ask and refine questions, using specific textual evidence, about the energy distribution in a system. Students should collect relevant data from several sources, including their own investigations, and synthesize their findings into a coherent understanding. Using the knowledge that energy cannot be created or destroyed, students should create computational or mathematical models to calculate the change in the energy in one component of a system when the change in energy of the other component(s) and energy flows in and out of the systems are known. In order to do this, students should manipulate variables in specific heat calculations. For example, students can use data collected from simple Styrofoam calorimeters to investigate the mixing of water at different initial temperatures or the adding of objects at different temperatures to water to serve as a basis for evidence of uniform energy distribution among components of a system. Students might conduct an investigation using different materials such as various metals, glass, and rock samples. Using the

specific heat values for these substances, students could create mathematical models to represent the energy distribution in a system, identify important quantities in energy distribution, map relationships, and analyze those relationships mathematically to draw conclusions.

These investigations will allow students to collect data to show that energy is transported from one place to another or transferred between systems, and that uncontrolled systems always move toward more stable states with more uniform energy distribution. Students should also observe during investigations that energy can be converted into less useful forms, such as thermal energy released to the surrounding environment. During the design and implementation of investigations, students must consider the precision and accuracy appropriate to limitations on measurement of the data collected and refine their design accordingly.

This unit will also focus on the planning and conducting of mechanical and chemical investigations of water. Properties to be investigated should include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks. This focus is particularly important since water's abundance on Earth's surface, and its unique combination of physical and chemical properties, are central to the planet's dynamics.

The functions and properties of water and water systems can be inferred from the overall structure, the way components are shaped and used, and the molecular substructure. Investigations will emphasize the mechanical and chemical processes involved in the interactions between the hydrological cycle and solid materials. Examples of mechanical investigations include stream transportation and deposition, erosion, and frost wedging. Examples of chemical investigations include chemical weathering, recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids). When investigating the properties of water and their effects on Earth materials and surface processes, students should report quantities using a level of accuracy appropriate to limitations on measurement.

To gain a more complete understanding, students might conduct short or more sustained research projects to determine how the properties of water affect Earth materials and surface processes. Once students have an understanding of the conservation of energy and the properties of water that allow it to absorb, store, and release large amounts of energy, the unit will transition to an engineering design problem.

Working from the premise that all forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs, risks, and benefits, students will use cost–benefit ratios to evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources.

For example, students might investigate the real-world technique of using hydraulic fracturing to extract natural gas from shale deposits versus other traditional means of acquiring energy from natural resources. Students will synthesize information from a range of sources into a coherent understanding of competing design solutions for extracting and utilizing energy and mineral resources. As students evaluate competing design solutions, they should consider that new technologies could have deep impacts on society and the environment, including some that were not anticipated. Some of these impacts could raise ethical issues for which science does not provide answers or solutions. In their evaluations, students should make sense of quantities and relationships associated with developing, managing, and utilizing energy and mineral resources. Mathematical models can be used to explain their evaluations. Students might represent their understanding by conducting a Socratic seminar as a way to present opposing views. Students should consider and discuss decisions about designs in scientific, social, and cultural contexts.

UNIT 2 Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum.

English Language Arts/Literacy

- Ask and refine questions to support uniform energy distribution among the components in a system when two components of different temperature are combined, using specific textual evidence.
- Conduct short as well as more sustained research projects to determine energy distribution in a system when two components of different temperature are combined.
- Collect relevant data across a broad spectrum of sources about the distribution of energy in a system and assess the strengths and limitations of each source.
- Synthesize findings from experimental data into a coherent understanding of energy distribution in a system.
- Conduct short as well as more sustained research projects to determine how the properties of water affect Earth materials and surface processes.
- Cite specific textual evidence to evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost–benefit ratios.
- Evaluate the hypotheses, data, analysis, and conclusions of competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost–benefit ratios, verifying the data when possible and corroborating or challenging conclusions with other design solutions.

- Integrate and evaluate multiple design solutions for developing, managing, and utilizing energy and mineral resources based on cost–benefit ratios in order to reveal meaningful patterns and trends.
- Evaluate the hypotheses, data, analysis, and conclusions of competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost–benefit ratios, verifying the data when possible and corroborating or challenging conclusions with other design solutions.
- Synthesize data from multiple sources of information in order to create data sets that inform design decisions and create a coherent understanding of developing, managing, and utilizing energy and mineral resources.

Mathematics

- Use symbols to represent energy distribution in a system when two components of different temperature are combined, and manipulate the representing symbols. Make sense of quantities and relationships in the energy distribution in a system when two components of different temperature are combined.
- Use a mathematical model to describe energy distribution in a system when two components of different temperature are combined. Identify important quantities in energy distribution in a system when two components of different temperature are combined and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities of the properties of water and their effects on Earth materials and surface processes.
- Use symbols to represent an explanation of the best of multiple design solutions for developing, managing, and utilizing energy and mineral resources and manipulate the representing symbols. Make sense of quantities and relationships in cost–benefit ratios for multiple design solutions for developing, managing, and utilizing energy and mineral resources symbolically and manipulate the representing symbols.
- Use a mathematical model to explain the evaluation of multiple design solutions for developing, managing, and utilizing energy and mineral resources. Identify important quantities in cost–benefit ratios for multiple design solutions for developing, managing, and utilizing energy and mineral resources and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

UNIT 2 Modifications for special education students, English language learners, students at risk of school failure and gifted students

Teacher Note: Teachers identify the modifications that they will use in the unit.

- ☐ Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)
- ☐ Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- ☐ Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- ☐ Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- ☐ Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- ☐ Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- ☐ Use project-based science learning to connect science with observable phenomena.
- ☐ Structure the learning around explaining or solving a social or community-based issue.
- ☐ Provide ELL students with multiple literacy strategies.
- ☐ Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 2 Research on Student Learning
Middle- and high-school student thinking about chemical change tends to be dominated by the obvious features of the change. For example, some students think that when something is burned in a closed container, it will weigh more because they see the smoke that was produced. Further, many students do not view chemical changes as interactions. They do not understand that substances can be formed by the recombination of atoms in the original substances. Rather, they see chemical change as the result of a separate change in the original substance, or changes, each one separate, in several original substances. For example, some students see the smoke formed when wood burns as having been driven out of the wood by the flame (NSDL, 2015).

UNIT 2 Prior Learning
Physical science • Substances are made from different types of atoms, which combine with one another in various ways. • Atoms form molecules that range in size from two atoms to thousands of atoms. • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others. • In a gas, they are widely spaced except when they happen to collide. • In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • Solids may be formed from molecules or they may be extended structures with repeating subunits (e.g., crystals). • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Substances react chemically in characteristic ways. • In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change. • Some chemical reactions release energy, others store energy. • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. • These physical and chemical properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting point of rocks.

UNIT 2 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.

Physical science

- Each atom has a charged substructure consisting of a nucleus made of protons and neutrons and surrounded by electrons.
- The periodic table orders elements horizontally by the number of protons in the nucleus of each element's atoms and places elements with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
- A stable molecule has less energy than does the same set of atoms separated; at least this much energy is required in order to take the molecule apart.
- Chemical processes, their rates, and whether or not they store or release energy can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.
- The fact that atoms are conserved in chemical reactions, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the energy stored in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Life Science

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

UNIT 2 Sample of Open Education Resources. Links to Free and Low Cost Instructional Resources

Note- *The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials.*

- American Association for the Advancement of Science: *http://www.aaas.org/programs*
- American Association of Physics Teachers: *http://www.aapt.org/resources/*
- American Chemical Society: *http://www.acs.org/content/acs/en/education.html*
- Concord Consortium: Virtual Simulations: *http://concord.org/*
- International Technology and Engineering Educators Association: *http://www.iteaconnect.org/*
- National Earth Science Teachers Association: *http://www.nestanet.org/php/index.php*
- National Science Digital Library: *https://nsdl.oercommons.org/*
- National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx
- North American Association for Environmental Education: *http://www.naaee.net/*
- Phet: Interactive Simulations *https://phet.colorado.edu/*
- Physics Union Mathematics (PUM): *http://pum.rutgers.edu/*
- Science NetLinks: *http://www.aaas.org/program/science-netlinks*

UNIT 2 Appendix A: NGSS and Foundations for the Unit

Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). *[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]* **(HS-PS3-4)**

Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. *[Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]* **(HS-ESS2-5)**

Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. *[Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]* **(HS-ESS3-2)**

Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. *[Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples]* **(HS-ETS1-3)**

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4)

Engaging in Argument from Evidence

- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations). (HS-ESS3-2)

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and

PS3.B: Conservation of Energy and Energy Transfer

- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-4)
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-4)

ESS3.A: Natural Resources

- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)

ETS1.B: Developing Possible Solutions

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2)

Influence of Science, Engineering, and Technology on Society and the Natural World

refine the design accordingly. (HS-ESS2-5) **Constructing Explanations and Designing Solutions** - Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)	- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary to HS-ESS3-2),(secondary HS-ESS3-4)* **ESS2.C: The Roles of Water in Earth's Surface Processes** - The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5) **ETS1.A: Defining and Delimiting Engineering Problems** - Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)	- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3) - ***Connections to Nature of Science*** **Science Addresses Questions About the Natural and Material World** - Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2) - Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2) - Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)

	- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) **ETS1.B: Developing Possible Solutions** - When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) - Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) **ETS1.C: Optimizing the Design Solution** - Criteria may need to be broken down into simpler ones can be approached systematically, and	

	decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)	

UNIT 2 Embedded English Language Arts/Literacy and Mathematics Standards
English Language Arts/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS3-4),(HS-ESS3-2)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-3)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-2),(HS-PS3-4),(HS-ETS1-3)

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS3-4), (HSESS2-5)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4)

Mathematics –

MP.2 Reason abstractly and quantitatively. (HS-PS3-4),(HS-ESS3-2),(HS-ETS1-3)

MP.4	Model with mathematics. (HS-PS3-4), (HS-ETS1-3)

Unit 2B: Energy of Chemical Systems Instructional Days: 20

1 This unit can be taught in either Chemistry or as part of the Capstone Science Course. If this unit is transferred to the Capstone Course, an abbreviated unit on Energy, based on HS—PS3-4, must be provided in its place.

This unit is based on HS-PS3-4.

UNIT 2b Summary Energy in Chemical Systems **Instructional Days: 20**

How is energy transferred within a system?

Unit 2B is used in a chemistry course when **Unit 2: The Chemistry of Abiotic Systems** is taught in the **Capstone Science Course**. In Energy of Chemical Systems, students will understand energy as a quantitative property of a system—a property that depends on the motion and interactions of matter and radiation within that system. They will also understand that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy, at both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy associated with the configurations (relative positions) of particles.

Students understand the role that water plays in affecting weather. Students can examine the ways that human activities cause feedback that create changes to other systems. Students are expected to demonstrate proficiency in *developing and using models*, *planning and carrying out investigations*, *analyzing and interpreting data*, *engaging in argument from evidence*, and using these practices to demonstrate understanding of core ideas.

UNIT 2b List of core instructional materials, including various levels of texts at each grade level benchmark assessments.

Textbook

Chemistry, Antony Wilbraham, (PEARSON-PRENTICE HALL: 2008)

Core Instructional Materials

- Laptop Cart
- Microsoft office
- CD-Rom Chemistry
- Internet resources
- Virtual Labs

UNIT 2b Student Learning

INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS

Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). *[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]* **(HS-PS3-4)**

Part A: *Does thermal energy always transfer or transform in predictable ways?* **CONNECTION TO LESSON PLAN HERE**	
Concepts	**Formative Assessment**
INSERT CHAPTER KEY CONCEPTS FROM	**INSERT CHAPTER OBJECTIVE FROM**

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. - Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. - Uncontrolled systems always move toward more stable states—that is, toward a more uniform energy distribution.	*Students who understand the concepts are able to:* - Plan and conduct an investigation individually or collaboratively to produce data on transfer of thermal energy in a closed system that can serve as a basis for evidence of uniform energy distribution among components of a system when two components of different temperatures are combined. - Use models to describe a system and define its boundaries, initial conditions, inputs, and outputs. - Design an investigation to produce data on transfer of thermal energy in a closed system that can serve as a basis for evidence of uniform energy distribution among components of a system

- Although energy cannot be destroyed, it can be converted into less useful forms—for example, to thermal energy in the surrounding environment.	when two components of different temperatures are combined, considering types, how much, and the accuracy of data needed to produce reliable measurements. - Consider the limitations of the precision of the data collected and refine the design accordingly

UNIT 2b What It Looks Like in the Classroom

In this unit of study, students begin by building their understanding of the law of conservation of energy by planning and conducting investigations of thermal energy transfer. Students should investigate and describe a system focusing specifically on thermal energy transfer in a closed system. These investigations will provide opportunities for students to use models that can be made of a variety of materials, such as student-generated drawings and/or digital simulations, such as those available from PhET. These models can be used to describe a system, and define its boundaries, initial conditions, inputs, and outputs.

Students should have the opportunity to ask and refine questions, using specific textual evidence, about the energy distribution in a system. Students should collect relevant data from several sources, including their own investigations, and synthesize their findings into a coherent understanding.

Using the knowledge that energy cannot be created or destroyed, students should create computational or mathematical models to calculate the change in the energy in one component of a system when the change in energy of the other component(s) and energy flows in and out of the systems are known. In order to do this, students should manipulate variables in specific heat calculations. For example, students can use data collected from simple Styrofoam calorimeters to investigate the mixing of water at different initial temperatures or the adding of objects at different temperatures to water to serve as a basis for evidence of uniform energy distribution among components of a system. Students might conduct an investigation using different materials such as various metals, glass, and rock samples. Using the specific heat values for these substances, students could create mathematical models to represent the energy distribution in a system, identify important quantities in energy distribution, map relationships, and analyze those relationships mathematically to draw conclusions.

These investigations will allow students to collect data to show that energy is transported from one place to another or transferred between systems, and that uncontrolled systems always move toward more stable states with more uniform energy distribution. Students should also observe during investigations that energy can be converted into less useful forms, such as thermal energy released to the surrounding environment. During the design and implementation of investigations, students must consider the precision and accuracy appropriate to limitations on measurement of the data collected and refine their design accordingly.

UNIT 2b Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum.

English Language Arts/Literacy-

- Ask and refine questions to support uniform energy distribution among the components in a system when two components of different temperature are combined, using specific textual evidence.
- Conduct short as well as more sustained research projects to determine energy distribution in a system when two components of different temperature are combined.
- Collect relevant data across a broad spectrum of sources about the distribution of energy in a system and assess the strengths and limitations of each source.

Mathematics-

- Use symbols to represent energy distribution in a system when two components of different temperature are combined, and manipulate the representing symbols. Make sense of quantities and relationships in the energy distribution in a system when two components of different temperature are combined.
- Use a mathematical model to describe energy distribution in a system when two components of different temperature are combined. Identify important quantities in energy distribution in a system when two components of different temperature are combined and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

UNIT 2 Modifications for special education students, English language learners, students at risk of school failure and gifted students

Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.

- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 2b Research on Student Learning

Middle- and high-school student thinking about chemical change tends to be dominated by the obvious features of the change. For example, some students think that when something is burned in a closed container, it will weigh more because they see the smoke that was produced. Further, many students do not view chemical changes as interactions. They do not understand that substances can be formed by the recombination of atoms in the original substances. Rather, they see chemical change as the result of a separate change in the original substance, or changes, each one separate, in several original substances. For example, some students see the smoke formed when wood burns as having been driven out of the wood by the flame (NSDL, 2015).

UNIT 2b Prior Learning

Physical science

- Substances are made from different types of atoms, which combine with one another in various ways.
- Atoms form molecules that range in size from two atoms to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others.
- In a gas, they are widely spaced except when they happen to collide.
- In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.
- Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, others store energy.

UNIT 2b Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.

Physical science

- Each atom has a charged substructure consisting of a nucleus made of protons and neutrons and surrounded by electrons.
- The periodic table orders elements horizontally by the number of protons in the nucleus of each element's atoms and places elements with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

- A stable molecule has less energy than does the same set of atoms separated; at least this much energy is required in order to take the molecule apart.
- Chemical processes, their rates, and whether or not they store or release energy can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.
- The fact that atoms are conserved in chemical reactions, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the energy stored in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Life Science

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

UNIT 2b Sample of Open Education Resources. Links to Free and Low Cost Instructional Resources

***Note-** The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. [The EQuIP Rubrics for Science]() can be used as a blueprint for evaluating and modifying instructional materials.*

- American Association for the Advancement of Science: *http://www.aaas.org/programs*
- American Association of Physics Teachers: *http://www.aapt.org/resources/*
- American Chemical Society: *http://www.acs.org/content/acs/en/education.html*
- Concord Consortium: Virtual Simulations: *http://concord.org/*
- International Technology and Engineering Educators Association: *http://www.iteaconnect.org/*
- National Earth Science Teachers Association: *http://www.nestanet.org/php/index.php*
- National Science Digital Library: *https://nsdl.oercommons.org/*
- National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx
- North American Association for Environmental Education: *http://www.naaee.net/*
- Phet: Interactive Simulations *https://phet.colorado.edu/*
- Physics Union Mathematics (PUM): *http://pum.rutgers.edu/*
- Science NetLinks: *http://www.aaas.org/program/science-netlinks*

UNIT 2b Appendix A: NGSS and Foundations for the Unit
Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). *[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include*

mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.] **(HS-PS3-4)**

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4)	**PS3.B: Conservation of Energy and Energy Transfer** - Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-4) - Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **PS3.D: Energy in Chemical Processes** - Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-4)	**Systems and System Models** - When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)

UNIT 2 Embedded English Language Arts/Literacy and Mathematics Standards
English Language Arts/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS3-4)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS3-4)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS3-4)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4)

Mathematics

MP.2 Reason abstractly and quantitatively. (HS-PS3-4)

MP.4 Model with mathematics. (HS-PS3-4)

Unit 3: Bonding and Chemical Reactions

Instructional Days: 30

This unit is based on HS-PS1-7, HS-PS1-4, HS-PS1-5, HS-

PS1-6, and HS- ETS1-2.

UNIT 3 Summary Bonding and Chemical Reactions Instructional Days: 30

How can one explain the structure, properties, and interactions of matter?

In this unit of study, students *develop and using models*, *plan and conduct investigations*, *use mathematical thinking*, and *construct explanations and design solutions* as they develop an understanding of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students also apply an understanding of the process of *optimization and engineering design* to chemical reaction systems. The crosscutting concepts of *patterns*, *energy and matter*, and *stability and change* are the organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in *developing and using models*, *planning and conducting investigations*, *using mathematical thinking*, and *constructing explanations and designing solutions*.

UNIT 3 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.

Textbook

Chemistry, Antony Wilbraham, (PEARSON-PRENTICE HALL: 2008)

Core Instructional Materials

- Laptop Cart
- Microsoft office
- CD-Rom Chemistry
- Internet resources
- Virtual Labs

UNIT 3 Student Learning **INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS &**
Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. *[Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]* **(HS-PS1-7)**
Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. *[Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]* **(HS-PS1-4)**
Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. *[Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]* **(HS-PS1-5)**
Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* *[Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]* **(HS-PS1-6)**

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS-ETS1-2)

UNIT 3 Quick Links

Part A: *Where do the atoms go during a chemical reaction?* **CONNECTION TO LESSON PLAN HERE**

Concepts	Formative Assessment
INSERT CHAPTER KEY CONCEPTS FROM	**INSERT CHAPTER OBJECTIVE FROM**

• The fact that atoms are conserved, together with the knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. • The total amount of energy and matter in closed systems is conserved. • The total amount of energy and matter in a chemical reaction system is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Changes of energy and matter in a chemical reaction system can be described in terms of energy and matter flows into, out of, and within that system.	*Students who understand the concepts are able to:* ☐ Use mathematical representations of chemical reaction systems to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. ☐ Use mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and products and the translation of these relationships to the macroscopic scale, using the mole as the conversion from the atomic to the macroscopic scale. ☐ Use the fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, to describe and predict chemical reactions.

	☐ Describe changes of energy and matter in a chemical reaction system in terms of energy and matter flows into, out of, and within that system.

Part B: *What is different inside a heat pack and a cold pack?*	
Concepts	**Formative Assessment**
☐ A stable molecule has less energy than the same set of atoms separated; at least this much energy must be provided in order to take the molecule apart. ☐ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. ☐ Changes of energy and matter in a chemical reaction system can be described in terms of collisions of molecules and the rearrangements of atoms into new molecules, with subsequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. ☐ Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	*Students who understand the concepts are able to:* ☐ Explain the idea that a stable molecule has less energy than the same set of atoms separated. ☐ Describe changes of energy and matter in a chemical reaction system in terms of energy and matter flows into, out of, and within that system. ☐ Describe chemical processes, their rates, and whether or not they store or release energy in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. ☐ Develop a model based on evidence to illustrate the relationship between the release or absorption of energy from a chemical reaction system and the changes in total bond energy.

Part C: *Is it possible to change the rate of a reaction or cause two elements to react that do not normally want to?*

Concepts	Formative Assessment
• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Patterns in the effects of changing the temperature or concentration of the reacting particles can be used to provide evidence for causality in the rate at which a reaction occurs.	*Students who understand the concepts are able to:* • Use the number and energy of collisions between molecules (particles) to explain the effects of changing the temperature or concentration of the reacting articles on the rate at which a reaction occurs. • Use patterns in the effects of changing the temperature or concentration of the reactant particles to provide evidence for causality in the rate at which a reaction occurs. • Apply scientific principles and multiple and independent student-generated sources of evidence to provide an explanation of the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Part D: *What can we do to make the products of a reaction stable?*	
Concepts	**Formative Assessment**
• Much of science deals with constructing explanations of how things change and how they remain stable. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others may be needed.	*Students who understand the concepts are able to:* • Construct explanations for how chemical reaction systems change and how they remain stable. • Design a solution to specify a change in conditions that would produce increased amounts of products at equilibrium in a chemical system based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

• Explanations can be constructed explaining how chemical reaction systems can change and remain stable.	• Break down and prioritize criteria for increasing amounts of products in a chemical system at equilibrium. • Refine the design of a solution to specify a change in conditions that would produce increased amounts of products at equilibrium in a chemical system based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

UNIT 3 What It Looks Like in the Classroom
The *Bonding and Chemical Reaction* unit ties together the concepts developed in *Structure and Properties of Matter* and *Energy and its Applications in Abiotic Systems* units (how to describe and predict chemical reactions, and energy flow and conservation within a system). In this unit, students will develop an understanding that the total amount of energy and matter in a closed system (including chemical reaction systems) is conserved and that changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Using this knowledge, and knowledge of the chemical properties of elements, students should be able to describe and predict simple chemical reactions in terms of mass and energy. The mole concept and stoichiometry are used to show proportional relationships between masses of reactants and products. Students should be able to use balanced equations to show mass relationships between reactants and products. Students should also gain an understanding of the use of dimensional analysis to perform mass to mole conversions that demonstrate how mass is conserved during chemical reactions. Focus should be on students' use of mathematics to demonstrate their thinking about proportional relationships among masses of reactants and products and to make connections between the atomic and macroscopic world. Students should use units appropriately and consistently, considering limitations on measurement, for the purpose of descriptive modeling of the proportional relationships between masses of atoms in the reactants and products and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. This unit also expands student understanding of the conservation of energy within a system by emphasizing the key idea that a stable molecule has less energy than the same set of atoms when separated. To support this concept, students might look at the change in energy when bonds are made and broken in a reaction system. Students might also analyze molecular-level drawings and tables showing energies in compounds with multiple bonds to show that energy is conserved in a chemical reaction.

In addition to conservation of energy, students should explore energy flow into, out of, and within systems (including chemical reaction systems). Students might be given data and asked to graph the relative energies of reactants and products to determine whether energy is released or absorbed. They should also conduct simple chemical reactions that allow them to apply the law of conservation of energy by collecting data from their own investigations. Students should be able to determine whether reactions are endothermic and exothermic, constructing explanations in terms of energy changes. These experiences will allow them to develop a model that relates energy flow to changes in total bond energy. Examples of models might include molecular-level drawings, energy diagrams, and graphs.

Students should expand their study of bond energies by relating this concept to kinetic energy. This can be understood in terms of the collisions of molecules and the rearrangement of atoms into new molecules as a function of their kinetic energy content. Students should also study the effect on reaction rates of changing the temperature and/or concentration of a reactant (Le Chatelier's principle). Students might explore the concept of equilibrium through investigations, which may include manipulations of variables such as temperature and concentration. Examples of these investigations may include the iodine clock reaction, the ferrous cyanide complex, as well as computer simulations such as those located at www.harpercollege.edu/tm-ps/chm/100/dgodambe/thedisk/equil/equil.htm. Using results from these investigations, students should develop an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs and on equilibrium. Students should be able cite evidence from text to support their explanations after conducting research.

Finally, in order to meet the engineering requirement for Unit 3, students should design a solution to specify a change in conditions that would produce increased amounts of products at equilibrium. As they consider their design, students should keep in mind that much of science deals with constructing explanations for how things change and how they remain stable. Through investigations and practice in changing reaction conditions (as mentioned above), as well as through teacher demonstrations such as MOM to the Rescue/Acid–Base Reaction (Flinn Scientific), students should come to understand that in many situations, a dynamic and condition dependent balance between a reaction and the reverse reaction determines the number of all types of molecules present. Examples of designs that students could refine might include different ways to increase product formation. Designs should include methods such as adding reactants or removing products as a means to change equilibrium. Students will base these design solutions on scientific knowledge, student-generated sources of evidence from prior investigations, prioritized criteria, and tradeoff considerations. They will do this in order to produce the greatest amount of product from a reaction system.

Integration of engineering -

The engineering performance expectation HS-PS1-1 calls specifically for a connection to HS-ETS1.C. To meet this requirement, HS-ETS1-2 has been identified as appropriate for this unit, since it directs students to design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. Students will design a solution to specify a change in conditions that would produce increased amounts of products at equilibrium.

UNIT 3 Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum.

English Language Arts/Literacy

- Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations showing that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy to enhance understanding of findings, reasoning, and evidence and to add interest.
- Cite specific textual evidence to support the concept that changing the temperature or concentration of the reacting particles affects the rate at which a reaction occurs.
- Develop an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples.
- Construct short as well as more sustained research projects to answer how to increase amounts of products at equilibrium in a chemical system. Synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Mathematics

- Represent an explanation that atoms, and therefore mass, are conserved during a chemical reaction symbolically and manipulate the representing symbols. Make sense of quantities and relationships about the conservation of atoms and mass during chemical reactions symbolically and manipulate the representing symbols.
- Use units as a way to understand the conservation of atoms and mass during chemical reactions; choose and interpret units consistently in formulas representing proportional relationships between masses of atoms in the reactants and products and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale; choose and interpret the scale and origin in graphs and data displays representing the conservation of atoms and mass in chemical reactions.

- Define appropriate quantities for the purpose of descriptive modeling of the proportional relationships between masses of atoms in the reactants and products and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale.
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities representing proportional relationships between masses of atoms in the reactants and products and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale.
- Use a mathematical model to explain how the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy, and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- Represent an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs symbolically and manipulate the representing symbols. Make sense of quantities and relationships about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs symbolically and manipulate the representing symbols.
- Use units as a way to understand an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. Choose and interpret units consistently in formulas representing the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. Choose and interpret the scale and the origin in graphs and data displays representing the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities representing the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
- Use a mathematical model to explain how to increase amounts of products at equilibrium in a chemical system. Identify important quantities in the cycling of matter and flow of energy among organisms in an ecosystem, and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

UNIT 3 Modifications for special education students, English language learners, students at risk of school failure and gifted students
Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.

- ☐ Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)
- ☐ Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- ☐ Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- ☐ Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- ☐ Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- ☐ Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- ☐ Use project-based science learning to connect science with observable phenomena.
- ☐ Structure the learning around explaining or solving a social or community-based issue.
- ☐ Provide ELL students with multiple literacy strategies.
- ☐ Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 3 Research on Student Learning
Middle- and high-school student thinking about chemical change tends to be dominated by the obvious features of the change. For example, some students think that when something is burned in a closed container, it will weigh more because they see the smoke that was produced. Further, many students do not view chemical changes as interactions. They do not understand that substances can be formed by the recombination of atoms in the original substances. Rather, they see chemical change as the result of a separate change in the original substance, or changes, each one separate, in several original substances. For example, some students see the smoke formed when wood burns as having been driven out of the wood by the flame (NSDL, 2015).

UNIT 3 Prior Learning

Physical science

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using models of matter. Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change. Some chemical reactions release energy; others store energy.
- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.
- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object or a ball, respectively).
- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- A system of objects may also contain stored (potential) energy, depending on their relative positions.
- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object or a ball, respectively).
- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- A system of objects may also contain stored (potential) energy, depending on their relative positions. Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

Life science

- Plants, algae (including phytoplankton), and many microorganisms use energy from light to make sugars (food) from carbon dioxide from the atmosphere and water, through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules to support growth or to release energy.
- Food webs are models that demonstrate how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

Earth and space sciences

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.

- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

UNIT 3 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.

Physical science

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position) of the particles. In some cases, the relative position of energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Life science

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

UNIT 3 Sample of Open Education Resources. Links to Free and Low Cost Instructional Resources
Note- The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials. ☐ American Association for the Advancement of Science: *http://www.aaas.org/programs* ☐ American Chemical Society: *http://www.acs.org/content/acs/en/education.html* ☐ Concord Consortium: Virtual Simulations: *http://concord.org/* ☐ International Technology and Engineering Educators Association: *http://www.iteaconnect.org/* ☐ National Earth Science Teachers Association: *http://www.nestanet.org/php/index.php*

- National Science Digital Library: *https://nsdl.oercommons.org/*
- National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx
- North American Association for Environmental Education: *http://www.naaee.net/*
- Phet: Interactive Simulations *https://phet.colorado.edu/*
- Science NetLinks: *http://www.aaas.org/program/science-netlinks*

UNIT 3 Appendix A: NGSS and Foundations for the Unit
Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. *[Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]* **(HS-PS1-7)**
Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. *[Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]* **(HS-PS1-4)**
Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. *[Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]* **(HS-PS1-5)**
Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* *[Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction*

systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.] **(HS-PS1-6)**
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS-ETS1-2)

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models - Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8) - Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) **Planning and Carrying Out Investigations** - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data	**PS1.A: Structure and Properties of Matter** - Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) - The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),*(secondary to HS-PS2-6)*	**Patterns** - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5) **Energy and Matter** - In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8) - The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) - Changes of energy and matter in a system can be described in terms of

(e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3) **Using Mathematics and Computational Thinking** - Use mathematical representations of phenomena to support claims. (HS-PS1-7) **Constructing Explanations and Designing Solutions** - Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) - Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6) **Asking Questions and Defining Problems**	- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) **PS1.B: Chemical Reactions** - Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5) - In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) - The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7) **PS1.C: Nuclear Processes**	energy and matter flows into, out of, and within that system. (HS-PS1-4) **Stability and Change** - Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) ----------------------------- *Connections to Nature of Science* **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** - Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) **Using Mathematics and Computational Thinking** - Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4) **Constructing Explanations and Designing Solutions** - Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) - Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)	- Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8) **PS2.B: Types of Interactions** - Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.*(secondary to HS-PS1-1),(secondary to HS-PS1-3)* **ETS1.C: Optimizing the Design Solution** - Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (secondary to HS-PS1-6) **ETS1.A: Defining and Delimiting Engineering Problems** - Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent	

	possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) - Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) **ETS1.B: Developing Possible Solutions** - When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) - Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)	

	ETS1.C: Optimizing the Design Solution - Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)	

UNIT 3 Embedded English Language Arts/Literacy and Mathematics Standards	
English Language Arts/Literacy	
RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-5)
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1),(HS-ETS1-3)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-5)

WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-6)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)
Mathematics -	
MP.2	Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7),(HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-PS1-4), (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-4),(HS-PS1-5),(HS-PS1-7)

Unit 4: Matter and Energy in Living Systems Instructional Days: 20

This unit is based on HS-LS1-7

and
HS-LS1-
6.

UNIT 4 Summary Matter and Energy Transformations in Living Systems Instructional Days: 20
How do organisms obtain and use the energy they need to live and grow? In this unit of study, students construct explanations for the role of energy in the cycling of matter in organisms. They apply mathematical concepts to develop evidence to support explanations of the interactions of photosynthesis and cellular respiration and develop models to communicate these explanations. The crosscutting concept of *matter and energy* provides students with insights into the structures and processes of organisms. Students are expected to *develop and use models*, *plan and conduct investigations*, *use mathematical thinking*, and *construct explanations and design solutions* as they demonstrate proficiency with the disciplinary core ideas.

UNIT 4 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.
Textbook Chemistry, Antony Wilbraham, (PEARSON-PRENTICE HALL: 2008) *Core Instructional Materials* • Laptop Cart • Microsoft office • CD-Rom Chemistry • Internet resources • Virtual Labs

UNIT 4 Student Learning INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS &
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. *[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]* **(HS-LS1-5)**
Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. *[Clarification Statement: Emphasis is on*

conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.] **(HS-LS1-7)**

Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. *[Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.]* **(HS-LS1-6)**

UNIT 4 Quick Links

Part A: *How does photosynthesis transform light energy into stored chemical energy?* CONNECTION TO LESSON PLAN HERE

Concepts INSERT CHAPTER KEY CONCEPTS FROM	Formative Assessment INSERT CHAPTER OBJECTIVE FROM
• The process of photosynthesis converts light energy to stored energy by converting carbon dioxide plus water into sugars plus released oxygen. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within a system.	*Students who understand the concepts are able to:* • Provide a mechanistic explanation for how photosynthesis transforms light energy into stored chemical energy. • Use their understanding of energy flow and conservation of energy to illustrate the inputs and outputs of matter and the transformation of energy in photosynthesis.

Part B: *How does cellular respiration result in a net transfer of energy?*

Concepts	Formative Assessment

• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. • Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. • Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. • Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.	*Students who understand the concepts are able to:* • Construct an evidence-based model, to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy. • Use their understanding of energy flow and conservation of energy to illustrate the inputs and outputs of the process of cellular respiration.

Part C: *How do elements of a sugar molecule combine with other elements and what molecules are formed?*	
Concepts	**Formative Assessment**
• Sugar molecules contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	*Students who understand the concepts are able to:* • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules. • Construct and revise an explanation, based on valid and reliable evidence from a variety of sources (including models, theories, simulations, peer review) and on the assumption that theories and laws that describe the natural world operate today as they

	did in the past and will continue to do so in the future, for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon based molecules. • Use evidence from models and simulations to support explanations for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.

UNIT 4 What It Looks Like in the Classroom
This unit of study continues to build on the concept of energy flow and matter discussed in units 1, 2, and 3; however it approaches the content from a life science standpoint. Students use their understanding of energy flow and conservation of energy to support their learning as they model photosynthesis and cellular respiration. Previous work with chemical reactions will help students develop explanations for the formation of amino acids and other large, carbon-based molecules. Also, students continue developing and using models, constructing explanations and designing solutions, and obtaining, evaluating, and communicating information. This unit of study continues looking at energy flow and matter but with emphasis on photosynthesis, cellular respiration, and polymerization. Students should use models such as diagrams, chemical equations, and conceptual models to illustrate how matter and energy flow through different organizational levels of living systems, from microscale to macroscale. In particular, both photosynthesis and cellular respiration will be the reactions used to emphasize that the reactants (inputs) and products (outputs) show the transfer of matter and energy from one system of interacting molecules to another. In developing models to represent how photosynthesis transforms light energy into stored chemical energy and the inputs and outputs of cellular respiration, students might use digital media in presentations to enhance understanding. *[Clarification, The focus of this unit is on the basic inputs and outputs of these processes. The specific biological steps of the Calvin cycle, Glycolysis, and Kreb cycle are not the focus this unit]*. Developing an understanding of photosynthesis and respiration will allow students to model radiant energy transferred from a macrosystem, such as the ocean, to a microsystem, such as an individual organism like plankton. In photosynthesis, light energy is converted to stored energy when carbon dioxide and water are converted into sugars. Oxygen is released in this process. The organism then converts the chemical energy into a usable form (A.T.P) on the cellular level through the process of cellular respiration. This process gives organisms the energy needed to

maintain life functions. An example is how some organisms need energy to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Models should use evidence to illustrate how photosynthesis transforms light energy into stored chemical energy; how cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy; and to illustrate the inputs and outputs of matter and the transformations of energy in both processes. Models could include chemical equations, flow diagrams, manipulatives, and conceptual models. Models should also illustrate that energy cannot be created or destroyed, and that it moves only between one place and another, between objects, or between systems.

At the same time, students take an in-depth look at the polymerization of sugar; they should research and investigate how simple sugars (made from carbon, hydrogen, and oxygen) are combined and recombined in different structures with specific functions. Students will construct and revise explanations for how simple sugars help form hydrocarbon backbones (amino acids) or carbon-based backbones (protein, DNA, new organism). Explanations should be supported and revised using evidence from multiple sources of text, models, theories, simulations, students' own investigations, and peer review. Students' explanations should describe the formation of amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA) that can be used, for example, to form new cells. It is important to remember that students are only required to conceptually understand the process, not the specific chemical reactions or the identification of macromolecules such as amino acids and DNA.

UNIT 4 Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum.

English Language Arts/Literacy

- Make strategic use of digital media in presentations to enhance understanding of how photosynthesis transforms light energy into stored chemical energy.
- Use digital media in presentations to enhance understanding of the inputs and outputs of the process of cellular respiration.
- Cite specific textual evidence to support how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.
- Use evidence from multiple sources to clearly communicate an explanation for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.

- Revise an explanation for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant.
- Draw evidence from informational texts to describe how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.

UNIT 4 Modifications for special education students, English language learners, students at risk of school failure and gifted students

Teacher Note: Teachers identify the modifications that they will use in the unit.

- ☐ Restructure lesson using Universal Design for Learning principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)
- ☐ Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- ☐ Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- ☐ Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- ☐ Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- ☐ Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- ☐ Use project-based science learning to connect science with observable phenomena.
- ☐ Structure the learning around explaining or solving a social or community-based issue.
- ☐ Provide ELL students with multiple literacy strategies.
- ☐ Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 4 Research on Student Learning

Students' meaning for "energy" both before and after traditional instruction is considerably different from its scientific meaning. In particular, students believe energy is associated only with humans or movement, is a fuel-like quantity which is used up, or is something that makes things happen and is expended in the process. Students rarely think energy is measurable and quantifiable.

Students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy change focus only on forms that have perceivable effects. The transformation of motion to heat seems to be difficult for students to accept, especially in cases with no obvious temperature increase. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen.

Some students of all ages have difficulty in identifying the sources of energy for plants and also for animals. Students tend to confuse energy and other concepts such as food, force, and temperature. As a result, students may not appreciate the uniqueness and importance of energy conversion processes like respiration and photosynthesis. Although specially designed instruction does help students correct their understanding about energy exchanges, some difficulties remain. [10] Careful coordination between The Physical Setting and The Living Environment benchmarks about conservation of matter and energy and the nature of energy may help alleviate these difficulties (NSDL, 2015).

UNIT 4 Prior Learning

Physical science

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, others store energy.
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Life science

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

UNIT 4 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.

Physical science

- Substances are made from different types of atoms, which combine with one another in various ways.
- Atoms form molecules that range in size from two to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, others store energy.
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Life science

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.

- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

UNIT 4 Sample of Open Education Resources. Links to Free and Low Cost Instructional Resources
Note- *The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials.* - American Association for the Advancement of Science: *http://www.aaas.org/programs* - American Chemical Society: *http://www.acs.org/content/acs/en/education.html*

- Concord Consortium: Virtual Simulations: *http://concord.org/*
- International Technology and Engineering Educators Association: *http://www.iteaconnect.org/*
- National Earth Science Teachers Association: *http://www.nestanet.org/php/index.php*
- National Science Digital Library: *https://nsdl.oercommons.org/*
- National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx
- North American Association for Environmental Education: *http://www.naaee.net/*
- Phet: Interactive Simulations *https://phet.colorado.edu/*
- Science NetLinks: *http://www.aaas.org/program/science-netlinks*

UNIT 4 Appendix A: NGSS and Foundations for the Unit
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. *[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]* **(HS-LS1-5)**
Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. *[Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]* **(HS-LS1-7)**
Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. *[Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.]* **(HS-LS1-6)**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models - Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-5),(HS-LS1-7) **Constructing Explanations and Designing Solutions** - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-6)	**LS1.A: Structure and Function** - Systems of specialized cells within organisms help them perform the essential functions of life. (secondary to HS-LS1-4, HS-LS1-5, HS-LS1-6) - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (secondary to HS-LS1-4, HS-LS1-5, HS-LS1-6) - Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (secondary to HS-LS1-4, HS-LS1-5, HS-LS1-6) - Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on	**Energy and Matter** - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6) - Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS1-7)

	inside the living system. (secondary to HS-LS1-4, HS-LS1-5, HS-LS1-6) **LS1.B: Growth and Development of Organisms** - In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4) **LS1.C: Organization for Matter and Energy Flow in Organisms** - The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5) - The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to	

make amino acids and other carbon-

	based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HS-LS1-6) - As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7) - As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7)	

UNIT 4 Embedded English Language Arts/Literacy and Mathematics Standards

English Language Arts/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-6)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-6)

WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS1-6)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS1-6)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-LS1-4),(HS-LS1-5),(HS-LS1-7)
Mathematics	
MP.4	Model with mathematics. (HS-LS1-4)
HSF-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-LS1-4)
HSF-BF.A.1	Write a function that describes a relationship between two quantities. (HS-LS1-4)

Unit 5: Nuclear Chemistry Instructional Days: 30

This unit is based on HS-PS1-8, HS-ESS1-3, HS-ESS1-1, HS-ESS1-2, and

HS-ESS1-6

UNIT 5 Summary Nuclear Chemistry Instructional Days: 30   ***What happens in stars?***   In this unit of study, energy and matter are studied further by investigating the processes of nuclear fusion and fission that govern the formation, evolution, and workings of the solar system in the universe. Some concepts studied are fundamental to science and demonstrate *scale, proportion, and quantity*, such as understanding how the matter of the world formed during the Big Bang and within the cores of stars over the cycle of their lives.   In addition, an important aspect of Earth and space sciences involves understanding the concept *of stability and change* while making inferences about events in Earth's history based on a data record that is increasingly incomplete the farther one goes back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record.   The crosscutting concepts of *energy and matter*; *scale, proportion, and quantity*; and *stability and change* are called out as organizing concepts for this unit. Students are expected to demonstrate proficiency in *developing and using models*; *constructing explanations and designing solutions; using mathematical and computational thinking; and obtaining, evaluating, and communicating information*; and they are expected to use these practices to demonstrate understanding of the core ideas.   *Note: This unit can be taught in either Chemistry or as part of the Capstone Science Course.*

UNIT 5 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.
Textbook   <u>Chemistry</u>, Antony Wilbraham, (PEARSON-PRENTICE HALL: 2008)   *Core Instructional Materials*   • Laptop Cart   • Microsoft office   • CD-Rom Chemistry   • Internet resources   • Virtual Labs

UNIT 5 Student Learning INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS &
Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. *[Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]* **(HS- PS1-8)**
Communicate scientific ideas about the way stars, over their life cycle, produce elements. *[Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]* **(HS-ESS1-3)**
Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. *[Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.]* **(HS-ESS1-1)**
Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. *[Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]* **(HS-ESS1-2)**

Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. *[Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]* **(HS-ESS1-6)**

UNIT 5 Quick Links

Part A: *Why is fusion considered the Holy Grail for the production of electricity?* Why aren't all forms of radiation harmful to living things?

CONNECTION TO LESSON PLAN HERE

Concepts **NSERT CHAPTER KEY CONCEPTS FROM**	**Formative Assessment** **INSERT CHAPTER OBJECTIVE FROM**
• Nuclear processes, including fusion, fission, and radioactive decay of unstable nuclei, involve release or absorption of energy. • The total number of neutrons plus protons does not change in any nuclear process. • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	*Students who understand the concepts are able to:* • Develop models based on evidence to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. • Use simple qualitative models based on evidence to illustrate the scale of energy released in nuclear processes relative to other kinds of transformations.

	• Develop models based on evidence to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of alpha, beta, and gamma radioactive decays.

Part B: *How do stars produce elements?*	
Concepts	**Formative Assessment**
• The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	*Students who understand the concepts are able to:* • Communicate scientific ideas in multiple formats (including orally, graphically, textually, and mathematically) about the way stars, over their life cycles, produce elements. • Communicate scientific ideas about the way nucleosynthesis, and therefore the different elements it creates, vary as a function of the mass of a star and the stage of its lifetime. • Communicate scientific ideas about how in nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Part C: *Is the life span of a star predictable?*	
Concepts	**Formative Assessment**
• The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. • Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. • The significance of the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth is	*Students who understand the concepts are able to:* • Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core in releasing energy that eventually reaches Earth in the form of radiation.

dependent on the scale, proportion, and quantity at which it occurs.	• Develop a model based on evidence to illustrate the relationships between nuclear fusion in the sun's core and radiation that reaches Earth.

Part D: *If there was nobody there to Tweet about it, how do we know that there was a Big Bang?*	
Concepts	**Formative Assessment**
• The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. • Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. • Energy cannot be created or destroyed, only moved between one place and another place, between objects and/or fields, or between systems. • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects	*Students who understand the concepts are able to:* • Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. • Construct an explanation of the Big Bang theory based on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars). • Construct an explanation based on valid and reliable evidence that energy in the universe cannot be created or destroyed, only moved between one place and another place, between objects and/or fields, or between systems.

may involve scientists, engineers, and others with wide ranges of expertise. • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and will continue to do so in the future. • Science assumes the universe is a vast single system in which basic laws are consistent. • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	

Part E: *How can chemistry help us to figure out ancient events?*	
Concepts	**Formative Assessment**
• Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.	*Students who understand the concepts are able to:* • Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. • Use available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. • Apply scientific reasoning to link evidence from ancient Earth materials, meteorites, and other planetary surfaces to claims about Earth's formation and early history, and assess the extent

• Much of science deals with constructing explanations of how things change and how they remain stable.	to which the reasoning and data support the explanation or conclusion. • Use available evidence within the solar system to construct explanations for how Earth has changed and how it remains stable.

UNIT 5 What It Looks Like in the Classroom

This unit of study continues looking at energy flow and matter but with a new emphasis on Earth and space science in relation to the history of Earth starting with the Big Bang theory. Students will also explore the production of elements in stars and radioactive decay. Students should develop and use models to illustrate the processes of fission, fusion, and radioactive decay and the scale of energy released in nuclear processes relative to other kinds of transformations, such as chemical reactions. Models should be qualitative, based on evidence, and might include depictions of radioactive decay series such as Uranium-238, chain reactions such as the fission of Uranium-235 in reactors, and fusion within the core of stars. Students could also explore the PhET nuclear fission inquiry lab and graphs to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of alpha, beta, and gamma radioactive decays. When modeling nuclear processes, students should depict that atoms are not conserved, but the total number of protons plus neutrons is conserved. Models should include changes in the composition of the nucleus of atoms and the scale of energy released in nuclear processes.

The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. Other than hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. Because atoms of each element emit and absorb characteristic frequencies of light, the presence of an element can be detected in stars and interstellar gases. Students should develop an understanding of how analysis of light spectra gives us information about the composition of stars and interstellar gases. Communication of scientific ideas about how stars produce elements should be done in multiple formats, including orally, graphically, textually, and mathematically. The conservation of the total number of protons plus neutrons is important in their explanations, and students should cite supporting evidence from text.

Students should also use the sun as a model for the lifecycle of a star. This model should also illustrate the relationship between nuclear fusion in the sun's core and energy that reaches the Earth in the form of radiation. Students could construct a mathematical model of nuclear fusion in the sun's core, identifying important quantities and factors that affect the life span of the sun. They should also be able to use units and consider limitations on measurement when describing energy from nuclear fusion in the sun's core that reaches the Earth. For example, students should be able to quantify the amounts of energy in joules when comparing energy sources. In this way, students will develop an understanding of how our sun changes and how it will burn out over a lifespan of approximately 10 billion years.

This unit continues with a study of how astronomical evidence ("red shift/blue shift," wavelength relationships to energy, and universe expansion) can be used to support the Big Bang theory. Students should construct an explanation of the Big Bang theory based on evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. Students should explore and cite evidence from text of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of primordial radiation that still fills the universe. The concept of conservation of energy should be evident in student explanations. Students should also be aware that a scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. Students should also know that if new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of the new evidence.

Students should be able to cite specific evidence from text to support their explanations of the life cycle of stars, the role of nuclear fusion in the sun's core, and the Big Bang theory. In their explanations, they should discuss the idea that science assumes the universe is a vast single system in which laws are consistent.

This unit concludes with the application of scientific reasoning and the use of evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of the Earth's formation and early history. For example, students will use examples of spontaneous radioactive decay as a tool to determine the ages of rocks or other materials (K-39 to Ar-40). Students should make claims about Earth's formation and early history supported by data while considering appropriate units, quantities and limitations on measurement. Students might construct graphs showing data on the absolute ages and composition of Earth's rocks, lunar rocks, and meteorites. Using available evidence within the solar system, students should construct explanations for how the earth has changed and how it has remained stable in its 4.6 billion year history.

UNIT 5 Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum.

English Language Arts/Literacy

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS1-1)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-3),(HS-ESS1-2)
SL.11-12.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-ESS1-3)
Mathematics	
MP.2	Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-2) ,(HS-ESS1-3) ,(HS-PS1-8)
MP.4	Model with mathematics. (HS-ESS1-1)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1),(HS-ESS1-2)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-2)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1), (HS-ESS1-2)
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1)
HSA-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-ESS1-1), (HS-ESS1-2)
HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1),(HS-ESS1-2)

UNIT 5 Modifications for special education students, English language learners, students at risk of school failure and gifted students

Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.

- ☐ Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)
- ☐ Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- ☐ Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- ☐ Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- ☐ Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- ☐ Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- ☐ Use project-based science learning to connect science with observable phenomena.
- ☐ Structure the learning around explaining or solving a social or community-based issue.
- ☐ Provide ELL students with multiple literacy strategies.
- ☐ Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 5 Research on Student Learning

1. Who asks the question? That is, who asks the question that focuses the investigation (e.g., "What effect does the tilt of the earth have on seasons?" or "What effect does pH have on litmus paper?" or "Which antacid best neutralizes acid?")? Is it the student or the teacher/book? In most curricula, these are an element given in the materials. As an educator you need to look for labs that, at least on a periodic basis, allow students to pursue their own questions.

2. Who designs the procedures? We are speaking here of lab procedures or the steps in an investigation. Who designs this process for gathering information? In order to gain experience with the logic underlying experimentation, students need continuous practice with designing procedures. Some labs, where the primary target is content acquisition, designate procedures. But others should ask students to do so.

3. Who decides what data to collect? This is similar to designing procedures, but the focus is on the data itself. What data is important and who determines that? Students need practice in determining the data to collect.

4. Who formulates explanations based upon the data? Do the text materials give the answers? Or do questions at the end of activities make students analyze and draw conclusions based on their data? The bottom line—Do the questions make students think?

5. Who communicates and justifies the results? Do activities push students to not only communicate but also justify their answers? Are activities thoughtfully designed and interesting so that students want to share their results and argue about conclusions?

UNIT 5 Prior Learning
Physical science

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, others store energy.

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Earth and space science

- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.
- Earth and its solar system are part of the Milky Way Galaxy, which is one of many galaxies in the universe.
- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.
- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- Because these patterns are so complex, weather can only be predicted probabilistically.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

UNIT 5 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.

Physical science

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.

- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places elements with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.
- Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.
- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
- When two objects interacting through a field change relative position, the energy stored in the field is changed.
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

- Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

Earth and space science

- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.
- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
- The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.
- Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.
- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.

UNIT 5 -Sample of Open Education Resources. Links to Free and Low Cost Instructional Resources
Note- *The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials.* ☐ American Association for the Advancement of Science: *http://www.aaas.org/programs* ☐ American Chemical Society: *http://www.acs.org/content/acs/en/education.html* ☐ Concord Consortium: Virtual Simulations: *http://concord.org/* ☐ International Technology and Engineering Educators Association: *http://www.iteaconnect.org/*

☐ National Earth Science Teachers Association: *http://www.nestanet.org/php/index.php* ☐ National Science Digital Library: *https://nsdl.oercommons.org/* ☐ National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx ☐ North American Association for Environmental Education: *http://www.naaee.net/* ☐ Phet: Interactive Simulations *https://phet.colorado.edu/* ☐ Science NetLinks: *http://www.aaas.org/program/science-netlinks*

UNIT 5 Appendix A: NGSS and Foundations for the Unit
Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. *[Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]* **(HS- PS1-8)**
Communicate scientific ideas about the way stars, over their life cycle, produce elements. *[Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]* **(HS-ESS1-3)**
Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. *[Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.]* **(HS-ESS1-1)**
Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. *[Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from*

galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).] **(HS-ESS1-2)**
Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. *[Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]* **(HS-ESS1-6)**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8),(HS-ESS1-1) **Constructing Explanations and Designing Solutions**	**PS1.C: Nuclear Processes** • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8) • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.(secondary (HS-ESS1-6)	**Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3), (HS-PS1-8), (HS-ESS1-1) • Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2) **Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS- ESS1-2) • Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) **Using Mathematical and Computational Thinking** Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions,	**ESS1.A: The Universe and Its Stars** • The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1) • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3) • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2) • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2),(HS-ESS1-3) **PS3.D: Energy in Chemical Processes and Everyday Life**	• Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4) • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2),(HS-ESS1-4) -

exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4) **Obtaining, Evaluating, and Communicating Information** • Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. (HS-ESS1-6) • Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3)	• Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary) (HS-ESS1-1) **PS4.B: Electromagnetic Radiation** • Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities.*(secondary)*HS-ESS1-2) **ESS1.B: Earth and the Solar System** • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4) **ESS1.C: The History of Planet Earth** • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information	***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2) • Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2) **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2)

	about Earth's formation and early history.	

UNIT 5 Embedded English Language Arts/Literacy and Mathematics Standards	
English Language Arts/Literacy -	
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS1-1)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-3),(HS-ESS1-2)
SL.11-12.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-ESS1-3)
Mathematics -	
MP.2	Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-2) ,(HS-ESS1-3) ,(HS-PS1-8)
MP.4	Model with mathematics. (HS-ESS1-1)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1),(HS-ESS1-2)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-2)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1), (HS-ESS1-2)

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HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1)
HSA-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-ESS1-1), (HS-ESS1-2)
HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1),(HS-ESS1-2)

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Unit 6: Human Impact: The Chemistry of Sustainability Instructional Days: 30

This unit is based on HS-ESS2-4; HS-ESS2-6; HS-ETS1-1; HS-ETS1-2; HS-ETS1-3;

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HS-ETS1-4

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UNIT 6 Summary Human Impact: The Chemistry of Sustainability Instructional Days: 30

How do Earth's geochemical processes and human activities affect each other?

In this unit of study, students use *cause and effect* to *develop models and explanations* for the ways that feedbacks among different Earth systems control the appearance of Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface (e.g., volcanism and mountain building), and the sun-driven surface systems that tear down the land through weathering and erosion. Students begin to examine the ways that human activities cause feedbacks that create changes to other systems. Students understand the *system interactions* that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students model the flow of energy and matter between different components of the weather system and how this affects chemical cycles such as the carbon cycle. Engineering and technology figure prominently here, as students use mathematical thinking and the analysis of geoscience data to examine and construct solutions to the many challenges facing long-term human sustainability on Earth. Here students will use these geoscience data to explain climate change over a wide range of timescales, including over one to ten years: large volcanic eruption, ocean circulation; ten to hundreds of years: changes in human activity, ocean circulation, solar output; tens of thousands to hundreds of thousands of years: changes to Earth's orbit and the orientation of its axis; and tens of millions to hundreds of millions of years: long-term changes in atmospheric composition).

Note: This unit can be taught in either Chemistry or as part of the Capstone Science Course.*

UNIT 5 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.

Textbook

Chemistry, Antony Wilbraham, (PEARSON-PRENTICE HALL: 2008)

Core Instructional Materials

- Laptop Cart
- Microsoft office
- CD-Rom Chemistry
- Internet resources
- Virtual Labs

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UNIT 6 Student Learning INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS &
Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. *[Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]* **(HS-ESS2-4)**
Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. *[Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]* **(HS-ESS2-6)**
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. *[Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-1)**
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. *[Note: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-2)**
Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. *[Note: See Three- Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-3)**
Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. *[Note: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-4)**

UNIT 6 Quick Links

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Part A: *What happens if we change the chemical composition of our atmosphere?* **CONNECTION TO LESSON PLAN HERE**	
Concepts **INSERT CHAPTER KEY CONCEPTS FROM**	**Formative Assessment** **INSERT CHAPTER OBJECTIVE FROM**
☐ The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. ☐ Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. ☐ The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	*Students who understand the concepts are able to:* ☐ Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. ☐ Use empirical evidence to differentiate between how variations in the flow of energy into and out of Earth's systems result in climate changes. ☐ Use multiple lines of evidence to support how variations in the flow of energy into and out of Earth's systems result in climate changes.

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☐ Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. ☐ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ☐ Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	

Part B: *How does carbon cycle among the hydrosphere, atmosphere, geosphere, and biosphere* **?**	
Concepts	**Formative Assessment**
☐ Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. ☐ Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. ☐ The total amount of energy and matter in closed systems is conserved. ☐ The total amount of carbon cycling among and between the hydrosphere, atmosphere, geosphere, and biosphere is conserved.	*Students who understand the concepts are able to:* ☐ Develop a model based on evidence to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. ☐ Develop a model based on evidence to illustrate the biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere, providing the foundation for living organisms.

UNIT 6 What It Looks Like in the Classroom

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This unit of study continues looking at matter and energy, with a focus on weather and climate, carbon cycling, and the cause-and-effect relationships between human activity and Earth's systems. Students will examine causes of variations in the flow of energy into and out of Earth's systems and how climate is affected by these variations. They will also determine how the amount of carbon cycling in Earth's systems has changed over time, and how humans are influenced by resource availability, natural hazards, and climate change.

Students should develop an understanding of how the foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. They should also examine how cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the Earth. These phenomena cause a cycle of ice ages and other gradual climate changes. Students might conduct research to locate and analyze data sets showing these phenomena.

In order to determine how changes in the atmosphere due to human activity have increased the carbon dioxide concentrations and affected climate, students should look at cycles of differing timescales and their effects on climate. Geoscience data should be used to explain climate change over a wide-range of timescales, including one to ten years: large volcanic eruptions, ocean circulation; ten to hundreds of years: changes in human activity, ocean circulation, solar output; tens of thousands to hundreds of thousands of years: changes to Earth's orbit and the orientation of its axis; and tens of millions to hundreds of millions of years: long-term changes in atmospheric composition. Students might also explore Earth's climate history through an analysis of datasets such as the Keeling Curve or Vostok ice core data.

Students can use a jigsaw activity to examine data for an assigned timescale and event to show cause-and-effect relationships among energy flow into and out of Earth's systems and the resulting in changes in climate.

Students should use models to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. Models should be supported by multiple lines of evidence, and students should use digital media in presentations to enhance understanding. Students might use mathematical models, and they should identify important quantities and map relationships using charts and graphs. Mathematical models should include appropriate units and limitations on measurement should be considered.

Students will continue their study of Earth's systems by examining the history of the atmosphere. Students should research the early atmospheric components and the changes that occurred due to plants and other organisms removing carbon dioxide and releasing oxygen. By studying the carbon cycle, students should revisit the idea that matter and energy within a closed system are conserved among the

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hydrosphere, atmosphere, geosphere, and biosphere. Students should extend their understanding of how human activity affects the concentration of carbon dioxide in the environment and therefore climate. Students' experiences should include synthesizing information from multiple sources and developing quantitative models based on evidence to describe the cycling of carbon among the ocean, atmosphere, soil, and biosphere.

Students should understand how biogeochemical cycles provide the foundation for living organisms. Once again, students might use a jigsaw activity to illustrate the relationships between these systems. Finally, making a connection to engineering, students will investigate the cause-and-effect relationships between the interdependence of human activities and Earth's systems. Students should construct an explanation based on evidence for relationships between human activity and changes in climate. Students can revisit the idea of renewable and nonrenewable resources touched upon in unit 4, and further investigate their availability. Examples of key natural resources should include access to fresh water, fertile soil, and high concentrations of minerals and fossil fuels. Students should also examine natural hazards including interior processes (volcanic eruptions and earthquakes); surface processes (tsunamis, mass wasting, and soil erosion); and severe weather (hurricanes, floods, and droughts). Additionally, other geologic events that have driven the development of human history (including populations and migrations) should also be researched. These geologic events include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised. Students must use empirical evidence to identify differences between cause and correlation in the relationship between climate changes and human activity. Students should also use empirical evidence to make claims about causes and effects of these interactions. The influence of major technological systems on modern civilizations should be emphasized. Because all the scientific and engineering practices and crosscutting concepts are necessary for mastery of the scientific content in this unit, it is an opportunity for students to engage in problem solving using the complete engineering design cycle. Research and examination of data to determine relationships between global change and human activity will allow students to identify and analyze a major global challenge.

Students should take into account possible qualitative and quantitative criteria and constraints for solutions and examine the needs of society in response to the identified major global challenge. The students could then design a solution to this real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. They must then evaluate their solution based on prioritized criteria and tradeoffs (e.g., cost, safety, reliability, aesthetics, and possible social, cultural, and environmental impacts). Finally, students might use computer simulations along with mathematics and computational thinking to model the impact of their proposed solution. Their simulation must take into account the numerous criteria and constraints on interactions within and between systems relevant to the problem. For example, major global challenges might include ozone depletion, melting glaciers, rising sea levels, changes in

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climate and extreme weather, ocean acidification, aerosols and smog, melting permafrost, destruction of rainforests, and biome migration. Some local challenges students might consider include fishing industry quotas vs. economic impact on local fishing fleets (i.e., New Bedford, Galilee, Jerusalem); flood plain construction vs. housing restrictions on ocean beach fronts (i.e., Mantoloking, Seaside Heights); design of possible solutions to retard or prevent further beach erosion; and response to recent flooding in Rhode Island and flood plain restoration.

Integration of engineering -

The standards in this unit do not identify a connection to engineering; however, the nature of the content lends itself to real-world problem identification and solution design, testing, and modification. Students can use their understanding of energy and matter and system interactions from the previous units to guide their thinking about climate change, its effects on humans, the adverse effects of human activities, and potential solutions to contemporary issues regarding climate change. In this unit, students have the opportunity to complete the entire engineering cycle (ETS1-1, ETS1-2, ETS1-3, and ETS1-4) by analyzing a major global challenge related to climate change and human activity, designing and evaluating a possible solution to this problem, and further using a computer simulation to model the impact of the proposed solution.

UNIT 6 Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum.

English Language Arts/Literacy-

- Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations describing how variations in the flow of energy into and out of Earth's systems result in changes in climate to enhance understanding of findings, reasoning, and evidence and to add interest.
- Cite specific textual evidence of the availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
- Use empirical evidence to write an explanation for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Mathematics-

- Represent symbolically an explanation for how variations in the flow of energy into and out of Earth's systems result in changes in climate, and manipulate the representing symbols. Use symbols to make sense of quantities and relationships about how variations in the flow of energy into and out of Earth's systems result in changes in climate, symbolically and manipulate the representing symbols.

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- ☐ Use a mathematical model to explain how variations in the flow of energy into and out of Earth's systems result in changes in climate. Identify important quantities in variations in the flow of energy into and out of Earth's systems result in changes in climate and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- ☐ Use units as a way to understand problems and to guide the solution of multistep problems about how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret units consistently in formulas representing how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret the scale and the origin in graphs and data displays representing how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- ☐ Define appropriate quantities for the purpose of descriptive modeling of how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- ☐ Choose a level of accuracy appropriate to limitations on measurement when reporting quantities to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- ☐ Represent symbolically the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere, and manipulate the representing symbols. Make sense of quantities and relationships in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
- ☐ Use a mathematical model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. Identify important quantities in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.
- ☐ Use units as a way to understand the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere; choose and interpret units consistently in formulas representing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere; choose and interpret the scale and the origin in graphs and data displays representing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
- ☐ Define appropriate quantities for the purpose of descriptive modeling of the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
- ☐ Choose a level of accuracy appropriate to limitations on measurement when reporting quantities showing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

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- Represent symbolically how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity, and manipulate the representing symbols. Make sense of quantities and relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
- Use units as a way to understand the relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity. Choose and interpret units consistently in formulas to determine relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity. Choose and interpret the scale and the origin in graphs and data displays representing relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
- Define appropriate quantities for the purpose of descriptive modeling of relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities showing relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

UNIT 6 Modifications for special education students, English language learners, students at risk of school failure and gifted students

Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.

- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)
- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.

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- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 6 Research on Student Learning

Students of all ages may confuse the ozone layer with the greenhouse effect, and may have a tendency to imagine that all environmentally friendly actions help to solve all environmental problems (for example, that the use of unleaded petrol reduces the risk of global warming). Students have difficulty linking relevant elements of knowledge when explaining the greenhouse effect and may confuse the natural greenhouse effect with the enhancement of that effect.

The idea of energy conservation seems counterintuitive to middle- and high-school students who hold on to the everyday use of the term energy, but teaching heat dissipation ideas at the same time as energy conservation ideas may help alleviate this difficulty. Even after instruction, however, students do not seem to appreciate that energy conservation is a useful way to explain phenomena. A key difficulty students have in understanding conservation appears to derive from not considering the appropriate system and environment. In addition, middle- and high-school students tend to use their conceptualizations of energy to interpret energy conservation ideas. For example, some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form. Or, students may believe that no energy remains at the end of a process, but may say that "energy is not lost" because an effect was caused during the process (for example, a weight was lifted). Although teaching approaches which accommodate students' difficulties about energy appear to be more successful than traditional science instruction, the main deficiencies outlined above remain despite these approaches (NSDL, 2015).

UNIT 6 Learning

Physical science-

- Substances are made from different types of atoms, which combine with one another in various ways.
- Atoms form molecules that range in size from two to thousands of atoms.

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- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.
- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- A system of objects may also contain stored (potential) energy, depending on the objects' relative positions.
- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

Life science-

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth or to release energy.
- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.
- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

Earth and space science-

- Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes.
- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, and a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and the gravitational movement of denser materials toward the interior.
- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.
- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.
- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.
- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.
- Resource availability has guided the development of human society.
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.
- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.
- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

UNIT 6 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.

Physical science-

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those elements with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.
- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases, the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Life science-

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.
- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, the ecosystem may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.

Earth and space sciences-

- Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.
- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.
- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.
- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

UNIT 6 Sample of Open Education Resources. Links to Free and Low Cost Instructional Resources

Note- *The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts.* The EQuIP Rubrics for Science *can be used as a blueprint for evaluating and modifying instructional materials.*

- American Association for the Advancement of Science: *http://www.aaas.org/programs*
- American Chemical Society: *http://www.acs.org/content/acs/en/education.html*
- Concord Consortium: Virtual Simulations: *http://concord.org/*
- International Technology and Engineering Educators Association: *http://www.iteaconnect.org/*

- National Earth Science Teachers Association: *http://www.nestanet.org/php/index.php*
- National Science Digital Library: *https://nsdl.oercommons.org/*
- National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx
- North American Association for Environmental Education: *http://www.naaee.net/*
- Phet: Interactive Simulations *https://phet.colorado.edu/*
- Science NetLinks: *http://www.aaas.org/program/science-netlinks*

UNIT 6 Appendix A: NGSS and Foundations for the Unit
Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. *[Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]* **(HS-ESS2-4)**
Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. *[Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]* **(HS-ESS2-6)**
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. *[Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-1)**
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. *[Note: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-2)**

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. *[Note: See Three- Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-3)**
Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. *[Note: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-4)**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models □ Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-1),(HS-ESS2-3),(HS-ESS2-6) □ Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4) **Asking Questions and Defining Problems** □ Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) **Using Mathematics and Computational Thinking** □ Use mathematical models and/or computer simulations to predict the	**ESS1.B: Earth and the Solar System** □ Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary to HS-ESS2-4)* **ESS2.A: Earth Materials and Systems** □ The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy	**Cause and Effect** □ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4) **Energy and Matter** □ The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6) **Systems and System Models** □ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)

effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4) **Constructing Explanations and Designing Solutions** - Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)	output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4) **ESS2.D: Weather and Climate** - The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4) - Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) - Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6),(HS-ESS2-4) **ETS1.A: Defining and Delimiting Engineering Problems**	- ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3) ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** - Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4)

	- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) - Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) **ETS1.B: Developing Possible Solutions** - When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) - Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of	

	solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) **ETS1.C: Optimizing the Design Solution** - Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)	

UNIT 6 Embedded English Language Arts/Literacy and Mathematics Standards

English Language Arts/Literacy

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1),(HS-ETS1-3)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1),(HS-ETS1-3)

Mathematics

MP.2	Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7),(HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-PS1-4), (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-4),(HS-PS1-5),(HS-PS1-7)

SCIENCE PROGRAM RUBRIC

Criterion A. All Standards, All Students

Guiding Question: To what extent does the science program ensures that ALL students are provided appropriate learning opportunities for ALL of the standards. This includes, but is not limited to, students with disabilities, economically disadvantages, English Language Learners, and students who have been identified as gifted?

NJSLS-S designed programs do *not* look like this:	NJSLS-S designed Science Programs look *more* like this:
The curriculum is based on the table of contents from science instructional materials.	Districts designed new science curricula by analyzing the new science standards and then intentionally selecting the instructional tasks and resources needed to move students toward proficiency.
Students learn science when time allows.	The district has a balanced curriculum in which all disciplines (e.g. Science, Social Studies, Visual and Performing Arts, and World Languages) are afforded adequate time and resources.
High School students take only biology, chemistry, and physics and not provided instruction in Earth and space science.	Regardless of course title, students have an opportunity to demonstrate proficiency with all of the Physical Science, Life Science and Earth and Space Science standards.
The curriculum is *aligned* to the standards.	• Science units in grades K-8 identify the previous learning and future learning for each unit. • High school science courses identify previous learning using the NJSLS-S and future learning referencing AP or IB course information for each course. • Accommodations for Access and Equity are part of the planning, not an add-on.

Criterion B. Explaining Phenomena or Designing Solutions

Guiding Question: To what extent do the units focus on supporting students to make sense of engaging and authentic phenomena or design solutions to real-world problem?

NJSLS-S designed units look *less* like this:	NJSLS-S designed units look *more* like this:

Explaining phenomena and designing solutions are not a part of student learning or are presented separately from “learning time” (i.e. used only as a “hook” or engagement tool; used only for enrichment or reward after learning; only loosely connected to a DCI).	The <u>purpose and focus</u> of the units are to support students in making sense of phenomena and/or designing solutions to problems. The entire lesson drives toward this goal.

The focus is only on getting the "right" answer to explain the phenomenon	Student sense-making of phenomena or designing of solutions is used as a window into student understanding of all three dimensions of the NJSLS-S.
A different, new, or unrelated phenomenon is used to start every lesson/unit.	Lessons/units work together in a coherent storyline to help students make sense of phenomena.
Teachers tell students about an interesting phenomenon or problem in the world.	Students get <u>direct</u> (preferably firsthand, or through media representations) experience with a phenomenon or problem that is relevant to them and is developmentally appropriate.
Phenomena are brought into the lessons/units after students develop the science ideas so students can apply what they learned.	The <u>development</u> of science ideas is anchored in explaining phenomena or designing solutions to problems.

<u>Criterion C. Three Dimensional</u>

<u>Guiding Question</u>: To what extent do the units help students develop and use multiple grade- appropriate elements of the science and engineering practices (SEP), disciplinary core ideas (DCI), and crosscutting concepts (CCC), which are deliberately selected to aid student sense-making of phenomena or designing of solutions?

NJSLS-S designed units look *less* like this:	NJSLS-S designed units look *more* like this:
A single practice element shows up throughout lessons.	Units help students use multiple (e.g., 2–4) practice elements as appropriate in their learning.
The units focuses on colloquial definitions of the practice or crosscutting concept names (e.g., "asking questions", "cause and effect") rather than on grade-appropriate learning goals (e.g., elements in NJSLS-S Appendices F &G).	Specific grade-appropriate elements of SEPs and CCCs (from NJSLS-S Appendices F & G) are <u>acquired</u>, <u>improved</u>, or <u>used</u> by students to help explain phenomena or solve problems during the lesson.
The SEPs and CCCs can be inferred by the teacher (not necessarily the students) from the lesson materials.	Students explicitly use the SEP and CCC elements to make sense of the phenomenon or to solve a problem.
Engineering lessons focus on trial and error activities that don't require science or engineering knowledge.	Engineering tasks require students to acquire and use elements of DCIs from physical, life, or Earth and space sciences together with elements of DCIs from engineering design (ETS) to solve design problems.

<u>Criterion D. Integrating the Three Dimensions for Instruction and Assessment</u>

<u>Guiding Question</u>: To what extent do the units require student performances that integrate elements of the SEPs, CCCs, and DCIs to make sense of phenomena or design solutions to problems, and the learning tasks elicit student artifacts that show direct, observable evidence of three-dimensional learning?

NJSLS-S designed units look *less* like this:	NJSLS-S designed units look *more* like this:

Students learn the three dimensions in isolation from each other (e.g., a separate lesson or activity on science methods followed by a later lesson on science knowledge).	• The units are designed to build student proficiency in at least one grade- appropriate element from each of the three dimensions. • The three dimensions intentionally work together to help students explain a phenomenon or design solutions to a problem. • All three dimensions are necessary for sense-making and problem-solving.
Teachers assume that correct answers indicate student proficiency without the student providing evidence or reasoning.	Teachers deliberately seek out student artifacts that show direct, observable evidence of learning, building toward all three dimensions of the NJSLS-S at a grade- appropriate level.
Teachers measure only one dimension at a time (e.g., separate items for measuring SEPs, DCIs, and CCCs).	Teachers use tasks that ask students to explain phenomena or design solutions to problems, and that reveal the level of student proficiency in all three dimensions.
English language arts and/or mathematics are added onto units.	Students are using grade appropriate English language arts and mathematics to make sense of phenomena or when designing a solution.

Criterion E. Relevance and Authenticity

Guiding Question: To what extent do the units motivate student sense-making or problem- solving by taking advantage of student questions and prior experiences in the context of the students' home, neighborhood, and community?

NJSLS-S designed units look *less* like this:	NJSLS-S designed lessons/units look *more* like this:
The units teach a topic adults think is important.	The units motivate student sense-making or problem-solving
The units focus on examples that some of students in the class understand.	The units provide support to teachers for making connections to the lives of every student in the class.
Driving questions are given to students.	Student questions, prior experiences, and diverse backgrounds related to the phenomenon or problem are used to drive the units and the sense- making or problem-solving.
The units tell the students what they will be learning.	The units provide support to teachers or students for connecting students' own questions to the targeted materials.

Criterion F. Student Ideas

Guiding Question: To what extent does the lesson provide opportunities for students to express, clarify, justify, interpret, and represent their ideas (i.e., making thinking visible) and to respond to peer and teacher feedback?

NJSLS-S designed units look *less* like this:	NJSLS-S designed units look *more* like this:
The teacher is the central figure in classroom discussions.	• Classroom discourse focuses on explicitly expressing and clarifying student reasoning • Students have opportunities to share ideas and feedback with each other directly.
Student artifacts only show answers.	Student artifacts include elaborations (which may be written, oral, pictorial, and digital) of reasoning behind their answers, and show how students' thinking has changed over time.
The teacher's guide focuses on what to tell the students.	The unit provides items, tasks, and/or prompts to teachers for eliciting student ideas.

Cr iterion G. Building on Students' Prior Knowledge

Guiding Question: To what extent does the units identify and build on students' prior learning in all three dimensions in a way that is explicit to both the teacher and students?

NJSLS-S designed units look *less* like this:	NJSLS-S designed units look *more* like this:
The unit content builds on students' prior learning, but only for DCIs.	The unit content builds on students' prior learning in all three dimensions.
The unit does not include support to teachers for identifying students' prior learning.	The lesson provides explicit support to teachers for identifying students' prior learning and accommodating different entry points, and describes how the lesson will build on the prior learning.
The unit assumes that students are starting from scratch in their understanding.	The unit explicitly works together with students' foundational knowledge and practice from prior grade levels.

PRIMARY EVALUATION OF ESSENTIAL CRITERIA (PEEC) NEXT GENERATION SCIENCE STANDARDS: FOR ALIGNMENT

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INTRODUCTION

In April 2013, release of the Next Generation Science Standards (NGSS) set new priorities for science education in the United States. The NGSS and the National Research Council's (NRC) *A Framework for K-12 Science Education*, on which the NGSS were based, describe a vision of science education that is based on scientific advances and educational research. This research and resulting vision for science education have implications for instructional materials that reach far beyond minor adjustments to lessons, a few new activities, and supplements to curriculum units. The innovations implied by the NGSS must be accommodated by changes to entire science instructional programs.

A prior document, the Educators Evaluating the Quality of Instructional Products (EQuIP) NGSS Rubric, provided criteria by which to measure the alignment and quality of *individual lessons and units* with respect to the NGSS. In contrast, the following discussion was designed to accompany the EQuIP rubric and to additionally present criteria and processes that can be used to evaluate the NGSS alignment of *entire school science programs* — that is, school curriculum, textbooks, and support materials for teachers that are designed for both year-long and K–12 education. The goal of this document is to describe some critical components of school science programs that are aligned with the NGSS. Shifting school programs to support the implementation of the NGSS will require many changes. The best response to this challenge would be to design brand new school science programs. This approach has the potential of developing a full school science program that most closely meets the vision described in *A Framework for K-12 Science Education*, the innovations set forth in the NGSS, and the recommendations from the foundational research. Although ideal, this approach has short term constraints of budget, time, and capacity to develop quality programs.

An alternative response to the short term needs is to adapt current instructional materials to incorporate the innovations described in the NGSS. This approach may address constraints of budget and time, but it may be significantly limited by the design of current programs and the degree to which the materials constituting those programs can be adapted to meet the NGSS.

Regardless of the approach, the first step is to thoroughly examine the differences between current science programs and those that are NGSS aligned. That is the primary emphasis of the following discussion.

REVIEWING INSTRUCTIONAL MATERIALS WITH PRIMARY EVALUATION OF ESSENTIAL CRITERIA FOR ALIGNMENT (PEEC-ALIGNMENT)

First, a few words about PEEC-Alignment. The acronym is intentionally a play on words. In one sense, the evaluation is a peek, or a quick look at a program. In another sense, this document describes a peak, the highest point, principal, or most important features of NGSS-aligned programs. PEEC-Alignment is designed to achieve both of these important goals.

Before conducting a complete and likely time-consuming review, it is most efficient to get a sense of the issues and make a decision about the need for a thorough and complete review.

This document is meant to help reviewers answer the question: “Does the program under review contain or exhibit the essential features of an NGSS-based program?” For this goal, PEEC-Alignment centers on the innovations set forth in the NGSS and their implications for instructional materials. If the program under review does not incorporate the most primary innovations set forth in the NGSS, then there is little need to conduct a full, detailed review to determine if materials are fully aligned to the NGSS. In other words, PEEC-Alignment is only meant to be an evaluation of NGSS alignment. There are many additional criteria for quality instructional materials that are not listed in this document. The omission is not because they are not critical criteria, but merely because they are not unique to NGSS- aligned materials. Existing lists of essential criteria for quality instructional materials can and should be added to those in this document to help complete a more comprehensive review process if materials pass a screen with the PEEC-Alignment.

PEEC-Alignment can be used to evaluate a comprehensive science program (e.g., a school program based on different units), kit-based instructional materials (e.g., a kit program for elementary science), textbooks (e.g., a middle school Earth science textbook), or textbook series (e.g., a K–6 elementary program) to determine the degree to which they align with the NGSS. The target materials can include full programs (e.g., spanning several grade levels), year-long courses (e.g., high school biology), and support materials in print or digital formats. However, evaluation of programs that are built from several different sources (e.g., a combination of textbooks, kits, and digital supplements) will often be more challenging if there is not clear guidance for how the different components will be used together in classrooms.

PEEC-Alignment is designed for publishers, curriculum developers, educators, and administrators responsible for developing, revising, selecting, or purchasing comprehensive programs, textbooks, or textbook series based on the NGSS.

PEEC-Alignment can be used by publishers as:

Standards-alignment specifications for designing a new comprehensive NGSS-based program; or

Indications of changes required for the revision of a current program.

PEEC-Alignment can be used by educators for:

Aiding decisions about the review, selection, and purchasing of school science textbooks, textbook series, and instructional materials that represent comprehensive programs; or

Evaluation of current materials to identify adaptations and modifications to increase alignment with the NGSS.

Beginning on page 22, the accompanying Appendix describes and guides the PEEC-Alignment review process. The primary innovations from the *Framework* and the NGSS along with their implications for instructional materials and school programs are described below. However, this document does not substitute for the breadth and depth of information contained in the NGSS and the *Framework*, and a thorough knowledge of these documents is necessary before attempting to apply the PEEC-Alignment process to instructional materials.

NGSS INNOVATIONS

The architecture of the NGSS differs significantly from prior standards for science education. In the NGSS, the three dimensions of Science and Engineering Practices (SEPs), Disciplinary Core Ideas (DCIs), and Crosscutting Concepts (CCCs) are crafted into performance expectations that describe what is to be assessable following instruction. The NGSS performance expectations are therefore a measure of competency. The foundation boxes for each of the three dimensions provide additional information and clarity for the design or redesign of school programs.

Figure 1. Example of NGSS Architecture for Standards

2-PS1-1 Matter and Its Interactions

Students who demonstrate understanding can:

2-PS1-1. **Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.** [Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Planning and Carrying Out Investigations	PS1.A: Structure and Properties of Matter	Patterns
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	• Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties.	• Patterns in the natural and human designed world can be observed.

Connections to other DCIs in second grade: N/A

Articulation of DCIs across grade-levels:
5.PS1.A

Common Core State Standards Connections:
ELA/Literacy —

W.2.7	Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-PS1-1)
W.2.8	Recall information from experiences or gather information from provided sources to answer a question. (2-PS1-1)

Mathematics —

MP.4	Model with mathematics. *(2-PS1-1)*
2.MD.D.10	Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. *(2-PS1-1)*

A comprehensive program should provide opportunities for students to develop their understanding of DCIs through their engagement in SEPs and their application of CCCs. This three-dimensional learning leads to eventual mastery of performance expectations. In this perspective, a quality program should clearly describe or show how the cumulative learning experience works coherently with previous and following experiences to build scientific literacy.

The following innovations in the NGSS are hallmarks of current thinking about how students learn science, and they set a vision for future science education. These innovations will not only cause a shift in instructional programs in American classrooms but should also affect and refocus the efforts of curriculum developers and the design of comprehensive school science programs.

Innovation 1: K–12 science education reflects three-dimensional learning.

In the NGSS, science is described as having three distinct dimensions, each of which represents equally important learning outcomes: (1) SEPs, (2) DCIs, and (3) CCCs (The Next Generation Science Standards 2013). The NGSS expectations for students include making connections among all three dimensions. Students develop and apply the skills and abilities described in the SEP, as well as learn to make connections between different DCIs through the CCC to help gain a better understanding of the natural and designed world. Current research suggests that both knowledge (DCIs and CCCs) and practice (SEPs) are necessary for a full understanding of science.

Each NGSS standard integrates one specific SEP, CCC, and DCI into a performance expectation that details what students should be proficient in by the end of instruction. In past standards the separation of skills and knowledge often led to an emphasis (in both instruction and assessment) on science concepts and an omission of inquiry and practices. It is important to note that the NGSS performance expectations do not specify or limit the intersection of the three dimensions in classroom instruction. Multiple SEPs, CCCs, and DCIs that blend and work together in several contexts will be needed to help students build toward competency in the targeted performance expectations. For example, if the end goal (the performance expectation) for students is to plan an investigation to determine the causes and effects of plant growth (2-LS2-1), they can build toward this goal through asking good questions about patterns that they have seen in plant growth and engaging in argument about what kinds of data would be important to collect in an investigation to answer these questions.

It should also be noted that one performance expectation should not be equated to one lesson. Performance expectations define the three-dimensional learning expectations for students, and it is unlikely that a single lesson would provide adequate opportunities for a student to demonstrate proficiency in every dimension of a performance expectation. A series of high-quality lessons or a unit in a program are more likely to provide these opportunities.

For more information about these three dimensions, see the NRC *Framework*, pages 29-33. Evaluating materials for three-dimensional learning is described in the EQuIP professional development module 6. Three-dimensional assessment of student learning is described in the document ***Developing Assessments for the Next Generation Science Standards*** (NRC 2014).

School programs must change:

From: providing discrete facts and concepts in science disciplines, with limited application of practice or the interconnected nature of the disciplines. Where crosscutting themes were included, they were implicit and not noticed or used by the student. Assessments within the programs exclusively addressed disciplinary concepts of science; neither the processes, inquiry, or SEPs nor the CCCs, unifying themes, or big ideas were included in the assessments.

To: providing learning experiences for students that blend multiple SEPs, CCCs, and DCIs — even those SEPs, CCCs, and DCIs not specified within the targeted performance expectations — with the goal that students are actively engaged in scientific processes to develop an understanding of each of the three dimensions. CCCs are included explicitly, and students learn to use them as tools to make sense of phenomena and make connections across disciplines. Assessments within the programs reflect each of the three distinct dimensions of science and their interconnectedness.

Innovation 2: Students engage in explaining phenomena and designing solutions.

In educational programs aligned to the NGSS, the goal of instruction is not solely for students to memorize content. Content becomes meaningful to students when they see its usefulness — when they need it to answer a question. Therefore, in programs aligned to the NGSS, an important component of instruction is to pique students' curiosity to help them see a need for the content.

The ultimate goal of an NGSS-aligned science education is for students to be able to explain real-world phenomena and to design solutions to problems using their understanding of the DCIs, CCCs, and SEPs. Students also develop their understanding of the DCIs by engaging in the SEPs and applying the CCCs. These three dimensions are tools that students can acquire and use to answer questions about the world around them and to solve design problems.

School programs must change:
From: focusing on disconnected topics, with content treated as an end in itself.
To: focusing on engaging students with meaningful phenomena or problems that can be explained or solved through the application of SEPs, CCCs, and DCIs. Instructional units that focus on students explaining relevant phenomena can provide the motivation students need to become invested in their own learning.

Innovation 3: The NGSS incorporate engineering design and the nature of science as SEPs and CCCs.

The NGSS include engineering design (see Appendices I and J) and the nature of science (see Appendix H) as significant elements. Some of the unique aspects of engineering design (e.g., identifying and designing solutions for problems), as well as common aspects of both science and engineering (e.g., designing investigations and communicating information), are incorporated throughout the NGSS as expectations for students from kindergarten through high school. In addition, unique aspects of the nature of science (e.g., scientific investigations use a variety of methods; scientific knowledge is based on empirical evidence; science is a way of knowing; science is a human endeavor) are included as SEPs and CCCs throughout the grade bands.

School programs must change:
From: presenting engineering design and the nature of science as supplemental or as disconnected from science learning (e.g., design projects that do not require science knowledge to complete successfully), with neither included in assessments.
To: incorporating learning experiences that include the DCIs of engineering design as well as the SEPs and CCCs of both engineering and the nature of science, with both included in assessments. Both engineering design and the nature of science are taught in an integrated manner with science disciplines (e.g., design projects require science knowledge in order to develop a good solution; the engineering process contributes to building science knowledge).

Innovation 4. SEPs, DCIs, and CCCs build coherent learning progressions from kindergarten to grade 12.

The NGSS provide for sustained opportunities from elementary through high school for students to engage in and develop a progressively deeper understanding of each of the three dimensions. Students require coherent learning progressions both within a grade level and across grade levels so they can continually build on and revise their knowledge to expand their understanding of each of the three dimensions by grade 12. See NGSS appendices E, F, and G for more information about the learning progressions for each dimension and how they build over time.

School programs must change:
From: a curriculum that lacks coherence in knowledge and experiences; provides repetitive, discrete knowledge that students memorize at each grade level; and often misses essential knowledge that has to be filled at later grade levels.
To: providing learning experiences for students that develop a coherent progression of knowledge and skills from elementary through high school. The learning experiences focus on a smaller set of disciplinary concepts that build on what has been learned in previous grades and provide the foundation for learning at the next grade span as detailed in the NGSS learning progressions.

Innovation 5. The NGSS connect to English language arts (ELA) and mathematics.

The NGSS not only provide for coherence in science teaching and learning but also unite science with other relevant classroom subjects: mathematics and ELA. This connection is deliberate because science literacy requires proficiency in mathematical computations and in communication skills. In fact, there are many inherent overlaps in the mathematics, ELA, and science practices (e.g., see the Stanford Understanding Language Initiative's Venn diagram). Therefore as the NGSS were being drafted, the writers ensured alignment to and identified some possible connections with the Common Core State Standards for ELA/literacy and mathematics as an example of ways to connect the three subjects. In instruction within the science classroom, mathematical and linguistic skills can be applied and enhanced to ensure a symbiotic pace of learning in all content areas. This meaningful and substantive overlapping of skills and knowledge helps provide all students equitable with access to the learning standards for science, math, and literacy (e.g., see NGSS Appendix D Case Study 4). The fact that science can be connected to the "basics" should not go unnoticed. Indeed, it presents science as a basic!

School programs must change:
From: providing siloed science knowledge that students learn in isolation from reading, writing, and arithmetic — the historical "basic" knowledge.
To: providing science learning experiences for students that explicitly connect to mathematics and ELA learning in meaningful and substantive ways and that provide broad and deep conceptual understanding in all three subject areas.

Figure 2 summarizes the NGSS innovations and components for the reform of comprehensive school science programs.

Figure 2. NGSS Innovations and Design of Instructional Materials

FROM	TO	CHANGE IN SCHOOL
Sole focus on discrete content	Integration of three dimensions (SEP, DCI, CCC)	Curriculum, instruction, and assessment
Learning content as the goal of lessons	Explaining phenomena through application of content as the goal of lessons	Curriculum and instruction
Engineering design and/or nature of science as supplemental	Engineering design and nature of science incorporated throughout science programs	Curriculum, instruction, and assessment
Concepts disconnected from prior learning	K–12 learning progressions	Curriculum, instruction, and assessment
Few connections to other subjects	Explicit connections to and alignment with ELA and mathematics	Curriculum and instruction

The implementation of NGSS-based reform has implications for all components of the school program and education system. The next sections discuss implications and recommendations for student materials, teacher materials and support, assessments within instructional materials, and how instructional materials can foster equitable opportunities to learn.

NGSS AND KEY COMPONENTS OF SCIENCE INSTRUCTIONAL MATERIALS

The quality of science instructional materials depends on many different aspects of the materials. This document will not attempt to describe all the important criteria for quality — for example, adherence to accessibility standards for design of student materials is critical but is beyond the scope of this document. Instead, the key components of quality materials listed below are merely a potential second step to a review process that begins with the PEEC-Alignment evaluation. If sufficient evidence is found for the presence of the NGSS innovations in instructional materials, then additional criteria should be considered to aid in an evaluation of quality.

Student Materials

A quotation from the *Framework* sets the stage for this section.

The learning experiences provided for students should engage them with fundamental questions about the world and how scientists have investigated and found answers to those questions. Throughout grades K–12, students should have the opportunity to carry out scientific investigations and engineering design projects related to the disciplinary core ideas. (*A Framework for K-12 Science Education* 2012)

The first sentence makes it clear that the activities in student materials should focus on fundamental questions about real-world phenomena and engage students in SEPs as they develop answers and scientific knowledge related to those questions. Later, the *Framework* introduces the innovations that student instructional materials should incorporate to facilitate student learning of the three dimensions (i.e., SEPs, DCIs, and CCCs) and the processes and products of science and engineering. Here is an example from the *Framework:*

Instructional materials must provide a research-based, carefully designed sequence of learning experiences that develop students' understanding of the three dimensions and also deepen their insights in the ways people work to seek explanations about the world and improve the built world. (*A Framework for K-12 Science Education* 2012)

Contemporary themes of focus, rigor, and coherence can be used to summarize key features of high-quality student instructional materials.

Focus: Student materials should focus on the limited number of DCIs in the NGSS, not numerous disconnected factoids and details. Focus should be on the core ideas in the NGSS — those that are most important for all students to learn. This focus will allow more time for students and teachers to explore core ideas in greater depth, so they can engage in SEPs to achieve deeper understanding of real-world phenomena and to explore the practical use of engineering design.

Rigor: Student instructional materials should support rigorous instruction for each of the three dimensions to allow for conceptual understanding, procedural skills, and applications of the NGSS. Knowledge and practice must be intertwined in learning experiences to support the depth of understanding that is needed to engage in scientific inquiry and engineering design. Learning experiences must provide opportunities for thought, discourse, and practice in an interconnected and social context so that students develop deep conceptual understanding and the ability to evaluate knowledge claims.

Coherence: Student materials should provide strong links among the three dimensions of the NGSS within and between each unit, grade level, and grade span for a unified learning experience. Learning experiences should form a progression in which students actively engage in SEPs and apply

CCCs to continually build on and revise their knowledge and abilities in each field's DCIs over multiple years. Student materials must provide clear guidance that (1) helps teachers support students' engagement in science and engineering to develop explanations for phenomena and design solutions to problems and (2) helps students develop increasingly sophisticated ideas within a grade level and across grades K–12. Student science learning experiences must also align well to their learning in mathematics and ELA.

Additional key recommendations for student materials include the following:

A focus on the central idea behind each SEP, CCC, and DCI for the target grade level.

Support for learning experiences that facilitate three-dimensional learning (i.e., each of the three dimensions is learned in the context of the other two — not on its own). These three-dimensional learning experiences go beyond the specific combination of the three dimensions in an individual performance expectation.

Learning experiences that are framed by contexts that are engaging and meaningful to the students and are centered on real-world phenomena and design problems.

Coherent units and instructional sequences that introduce material in a logical manner, without requiring students to use concepts before they have been taught. For example, NGSS Appendix K describes some sample course arrangements for middle and high school that provide vertical coherence. Grade level-appropriate learning experiences that explicitly involve the application of knowledge and skills learned in prior grades or earlier in the year.

Instructional sequences that provide multiple opportunities and contexts in which to explicitly encounter each idea (including each of the three dimensions) and skill, as well as adequate time to build toward student proficiency as described by the NGSS Evidence Statements by the end of the year or end of the unit.

Instructional sequences that have clear purposes for students' experiences (e.g., teach new knowledge, expose current misconceptions, build skills and abilities).

Learning goals (including for each of the three dimensions) that are explicit for students and provide opportunities for students to reflect on their learning.

Scientific accuracy and grade-level appropriateness.

Adherence to safety rules and regulations.

Thorough materials lists as needed. Such lists should identify expendable and permanent materials needed for both instruction and assessment.

High-quality (e.g., durable, dependable, functioning as intended) materials, equipment in kits, technological components, or online resources, where applicable.

Technological system requirements, where applicable.

Teacher Materials and Support

Teacher materials are a fundamental aspect of science classroom instruction. Components of teacher materials typically include annotated student texts, ancillary student materials designed to enhance or remediate, manuals of worksheets, yearly maps of content, suggestions for developing daily lessons, and lists of lab equipment used in the program. These components of the teacher materials have been and will continue to be useful for teachers in planning and supporting their instruction.

However, the NRC's *Framework* and the subsequent NGSS have set a new vision of science education for K–12 students. This vision includes defining the knowledge and practices critical for understanding the natural world. The vision set forth by the NGSS and the NRC's *Framework* provides new challenges for those developing teacher materials. One challenge will be how to support teachers as they translate the new ideas into classroom practices. Research recognizes that expert teachers and leaders are perhaps the most important resources for improving student learning (Darling-Hammond 2000). Teacher materials will be necessary in this work but will need to be redesigned to facilitate both teacher understanding and ability to instruct their students.

NGSS-aligned instructional materials must focus on the three dimensions: SEPs, CCCs, and DCIs. Understanding each dimension and how they interact with each other will be critical for teachers as they begin to design instruction that intertwines and builds deeper understanding of the dimensions. Instructional materials developers can aid in increasing understanding of the three dimensions by providing ample annotations and suggestions on how to combine the three dimensions to engage students in developing explanations and constructing conceptual models of the natural world. Carefully planned authentic exploration of phenomena and a wide variety of instructional strategies will enable teachers to provide classroom experiences that will help students experience three-dimensional learning. In addition, the materials will need to develop articulated conceptual flows or learning progressions of content not only within each grade level but also across grade levels to aid the teacher's understanding and instruction of the three dimensions.

Some key ideas, strategies, and components to consider in developing instructional materials to aid teachers include the following:

Grade-appropriate background information for each of the three dimensions and an explanation of how the three disciplines interact within the grade, unit, and lesson levels.

A detailed yearlong map of the suggested learning progressions that could be used in planning the day-to-day instruction. Additionally, showing how the grade levels connect for coherence and build for greater sophistication of student understanding will be helpful.

Strategies that include appropriate and integral connections between science and other subject areas (e.g., mathematics, ELA, history/social science, visual and performing arts, career and technical education).

Guidance on strategies to interweave some of the "hands-on" practices (e.g., carrying out investigations, designing solutions) with science learning activities that use other practices (e.g., asking questions; engaging in argument; obtaining, evaluating, and communicating information) to bring about integrated instructional units.

Embedded instructional strategies throughout the instructional materials (e.g., scaffolding, note booking, think-pair-share, quick writes, open-ended questioning, cooperative learning, Socratic seminars, direct instruction, small-group instruction).

Strategies to identify the reason(s) that student may have difficulty in mastering or demonstrating their mastery of the three dimensions of the NGSS.

Strategies that effectively assess student knowledge and skills related to the three dimensions of the NGSS.

Strategies including alternative approaches and delivery mechanisms (e.g., computer-based instruction, web-based materials) that will assist in differentiating instruction to meet the needs of all students (e.g., English language learners, special needs students, advanced learners, struggling students) and adapt to different learning styles.

Strategies that help identify ways in which activities or learning experiences can be contextualized to the school environment.

An annotated list of resource materials, both expendable (e.g., cotton balls, pinto beans) and permanent (e.g., lab equipment), that are to be used throughout the program, including possible safety practices and room arrangements.

Suggestions on types of professional development and learning experiences necessary for successful implementation.

Assessment in Instructional Materials

Classroom assessments are an integral part of instruction and learning and should include both formative and summative tasks. Formative tasks are those that are specifically designed to guide instructional decision making and lesson planning. Summative tasks are those that are specifically designed to assess student learning at the end of an instructional sequence, unit, grade level, or grade band (National Research Council 2014). Curriculum developers, assessment developers, and others who create resource materials aligned to the NGSS should ensure that assessment activities included in materials (such as formative assessment suggestions to teachers, mid- and end-of-chapter activities, tasks for unit assessments, and online activities) engage students in SEPs that demonstrate their understanding of DCIs and CCCs. These assessment materials also should reflect multiple dimensions of diversity (e.g., by connecting with students' cultural and linguistic identities). In designing instructional materials that include formative and summative assessments, development teams should include experts in science, science learning, assessment design, equity, diversity, and science teaching (National Research Council 2014).

Assessment tasks must be designed to provide evidence of students' ability to use the SEPs, to apply their knowledge of CCCs, and to draw on their understanding of DCIs, all in the context of addressing specific problems or answering certain questions (National Research Council 2014). Instruction and assessments must be designed to support and monitor students as they develop increasing sophistication in their ability to use SEPs, apply CCCs, and understand DCIs as they progress through the year and across the grade levels. An example of creating and assessing these smaller scale learning goals can be found in "Planning Instruction to Meet the Next Generation Science Standards" (Krajcik et al. 2014). Assessment developers should draw on the idea of developing understanding as they structure tasks for different levels and purposes and build this idea into the scoring rubrics for the tasks (National Research Council 2014). Although factual knowledge is fundamental and understanding the language and terminology of science is very important, tasks that demand only declarative knowledge about practices or isolated facts would be insufficient to measure performance expectations in the NGSS (National Research Council 2014).

Effective evaluation of three-dimensional science learning requires more than a one-to-one mapping between the NGSS performance expectations and assessment tasks. It is important to note that more than one assessment task may be required to adequately assess students' mastery of some performance expectations, and any given assessment task may assess aspects of more than one performance expectation. In addition, to assess both understanding of core knowledge and facility with a practice, assessments may need to probe students' use of a given practice in more than one disciplinary context. To adequately cover the three dimensions, assessment tasks will generally need to contain multiple components (e.g., a set of interrelated questions). Developers might focus on individual SEPs, DCIs, or CCCs in some components of an assessment task, but together, the components need to support inferences about students' three-dimensional science learning as described in a given performance expectation. Assessment tasks that attempt to test practices in strict isolation likely will not be as meaningful as assessments of the three-dimensional science learning called for by the NGSS (National Research Council 2014).

Key points regarding classroom assessments to support the NGSS:

Assessments are aligned with the NGSS; are authentic; and include pre-assessments, formative assessments, summative assessments, and self-monitoring measures.
Assessments collect data on all three dimensions of the NGSS and on how the students are using the different dimensions in concert with one another.
Assessments have explicitly stated purposes and are consistent with the decisions they are designed to inform.
Assessments are embedded throughout instruction materials as tools for students' learning and teachers' monitoring of instruction.
Assessments reflect only knowledge and skills that have been covered adequately in the instructional materials.
Assessments use varied methods, language, representations, and examples that are unbiased and accessible to all students and provide teachers with a range of data to inform instruction.

For more information regarding classroom assessment and the NGSS, see the following in the NRC's report, *Developing Assessments for the Next Generation Science Standards* (2014):
Chapter three provides in-depth information about how to design NGSS- appropriate assessment tasks and includes examples.
Chapter four illustrates the types of assessment tasks that can be used in the classroom to meet the goals of the NRC's *Framework* and the NGSS.

Equitable Opportunity to Learn in Instructional Materials

The NGSS offer a vision of science teaching and learning that presents both opportunities and demands for ALL students. The NGSS highlight issues related to equity and diversity and offer specific guidance for fostering science learning for diverse groups (see NGSS, Appendix D). Issues related to equity and diversity become even more important when standards are translated into curricular and instructional materials and assessments. Opportunity to learn is a crucial component in the design of resources and includes instructional time, equipment, materials, and well-prepared teachers. Instructional resources should support teachers in meeting the needs of diverse students and in identifying, drawing on, and connecting with the advantages their diverse experiences give them for learning science (National Research Council 2014). The focus on engaging real-world phenomena and design problems offers multiple entry points to build and deepen understanding for all students. The SEPs offer rich opportunities for language learning while they support science learning for all students (National Research Council 2012).

All students bring their own knowledge and understanding about the world when they come to school. Their knowledge and understanding is based on their experiences, culture, and language (National Research Council 2007). Their science learning will be most successful if curriculum, instruction, and assessments draw on and connect with these experiences and are accessible to students linguistically and culturally (Rosebery et al. 2010; Rosebery and Warren 2008; Warren and Ogonowski 2005; Warren, Ballenger, et al. 2001; National Research Council 2014). Researchers who study English language learners also stress the importance of a number of strategies for engaging those students, and they note that these strategies can be beneficial for all students. For example, techniques used in literacy instruction can be used in the context of science learning. These strategies promote comprehension and help students build vocabulary so they can learn content at high levels while their language skills are developing (Lee and Maerten-Rivera 2012; Lee, Quinn, and Valdez 2013; National Research Council 2014).

Key points regarding instructional materials that support equitable opportunity to learn the NGSS
:

The materials provide guidance for teaching diverse student groups, including visually impaired students, hearing impaired students, students with special needs, talented and gifted students, and English language learners.
Students have adequate opportunities to demonstrate their understandings and abilities in a variety of ways and appropriate contexts.
The focus phenomena for each course, unit, or lesson are chosen carefully, taking into account the interest and prior experiences of diverse students. When phenomena are not relevant or clear to some students (e.g., crop growth on farms), alternate engaging phenomena are suggested to the teacher.
The materials provide extensions consistent with the learning progression for students with high interest or who have already met the performance expectations. The NGSS assessment boundaries are intended to limit large-scale assessment and not to limit extension opportunities for students.
The texts recognize the needs of English language learners and help them both access challenging science and develop grade-level language. For example, materials might include annotations to help with comprehension of words, sentences, and paragraphs and give examples of the use of words in other situations. Modifications to language should neither sacrifice the science content nor avoid necessary language development.
The language used to present scientific information and assessments is carefully considered and should change with the grade level and across science content.
The materials provide the appropriate reading, writing, listening, and/or speaking modifications (e.g., translations, front-loaded vocabulary word lists, picture support, graphic organizers) for students who are English language learners, have special needs, or read below the grade level.
The materials provide extra support for students who are struggling to meet the performance expectations.

For more information regarding equitable learning opportunities, research-based strategies for effective implementation, context for student diversity, and the NGSS, see the following:
Next Generation Science Standards Appe ndix D, “All Standar ds, All Students.”
Seven case studies that illustrate science teaching and learning of nondominant student groups as they engage in the NGSS.

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504 PLAN STUDENTS

Students who are eligible for accommodations or modifications under Section 504 of the Rehabilitation Act of 1973 may not be classified as special education, but have an impairment of a major life function such as performing manual tasks, walking, seeing, hearing, speaking etc. Any accommodations or modifications for Section 504 eligible students must be specified in the student's accommodation plan and must be consistent with the instruction and assessment procedures in the classroom.

LIMITED-ENGLISH PROFICIENT

All Limited-English Proficient (LEP) students must take the New Jersey statewide assessments and may be tested with one or more accommodations in the test administration procedure. These accommodations may include:
additional time up to 150% of the administration times indicated;
translation of the test directions only into the student's native language; and
use of a Bilingual translation dictionary.

ACCOMMODATIONS

An accommodation can be made for any student, not just students with a 504 plan or an IEP. An accommodation does not alter what the student is expected to learn. An accommodation makes learning accessible to the student and allows the student to demonstrate what they know. Accommodations are alterations in the way tasks are presented that allow children with a disability to complete the same assignments as other children.
Accommodations do not alter the content of assignments, give students an unfair advantage or in the case of assessments, change what a test measures. They do make it possible for students with LD to show what they know without being impeded by their disability.
Accommodations are basically physical or environmental changes, generally referred to as good teaching strategies.
 Extended time, frequent breaks, varying of activities

 Change in classroom, preferential seating, physical arrangement of the room, reducing/minimizing distractions, cooling off period
 Emphasizes varied teaching approaches (visual, auditory, multi-sensory), individual or small group, demonstrating/modeling, visual cues, use of manipulatives, pre-teaching, graphic organizers
 Highlighting material, note taking assistance, notes provided by teacher, calculator, computer, word processor, Braille, and/or large print
 Directions given in small, sequential steps, copying from book
 Positive reinforcement, concrete reinforcement, checking for understanding, study guides, before/after school tutoring
 Reading test verbatim, shortening length of test, test format changed (multiple choice vs. fill in the blank)
 Allow for verbal responses

Should accommodations have an impact on how assignments are graded?
School assignments and tests completed with accommodations should be graded the same way as those completed without accommodations. After all, accommodations are meant to “level the playing field,” provide equal and ready access to the task at hand, and not meant to provide an undue advantage to the user.

What if accommodations don’t seem to be helping? Selecting and monitoring the effectiveness of accommodations should be an ongoing process, and changes (with involvement of students, parents and educators) should be made as often as needed. The key is to be sure that chosen accommodations address students’ specific areas of need and facilitate the demonstration of skill and knowledge.

MODIFICATIONS
Modifications are generally made for students with significant cognitive or physical disabilities. A modification does alter content knowledge expectations as well as assessment administration practices. A modification is a change in the course of study, standards, test preparation, location, timing, scheduling, expectations, student response and/or other attribute which provide access for a student with a disability to participate in a course, standard or test. It does fundamentally alter or lower the standard or expectation of the course, standard or test.

Modifications are used in the classroom to meet the needs of every child’s strength.

Modifications involve lowering the level of materials presented.
 Presentation of curriculum is modified using a specialized curriculum which is written at a lower level of understanding.
 Materials are adapted; texts are simplified by modifying the content areas—simplifying vocabulary, concepts and principles.
 Grading is subject to different standards than general education, such as based on IEP goals.
 Assignments are changed using lower level reading levels, worksheets and simplified vocabulary.
 Testing Adaptations are used, such as lowering the reading level of the test.

Accommodations vs. Modifications

Accommodations level the playing field while Modifications c hange the field you're play ing on.

□ Decisions must be based on the child's unique and individualized need, not on what we do for all kids with a particular classification.

□ The use of accommodations or modifications should enable the child to demonstrate progress.

□ Individual Education Plans should offer children equal opportunity for success.

INTERVENTIONS

An intervention is a specific skill-building strategy implemented and monitored to improve a targeted skill (i.e. what is actually known) and achieve adequate progress in a specific area (academic or behavioral). This often involves a changing instruction or providing additional instruction to a student in the area of learning or behavior difficulty.

Academic or behavior interventions are strategies or techniques applied to instruction in order to teach a new skill, build a fluency skill, or encourage the application of existing skills to a new situation. Interventions require a targeted assessment, planning, and date collection. Interventions should be evidence based and monitored regularly to determine growth and to inform instruction.

Interventions differ from accommodations and modifications in that they teach new skills to help students overcome specific deficits or maladaptive response patterns.

Interventions require a targeted assessment, planning, and data collection (ideally including baseline data) to be effective. Consideration is given to the nature of the problem (i.e. skill deficit versus performance deficit).

Interventions focus on the needs of the "individual" student.

ACCOMMODATIONS, INTERVENTIONS, MODIFICATIONS CHART

Accommodations	Interventions	Modifications
Accommodate is defined as "to make fit." It is similar to adaptation. Accommodations and adaptations are used to describe how students are included in classroom instruction. Changes to the classroom structure, both organizationally and instructionally that allows a student to participate.	An intervention is defined as "to come between." Doctors use medications for intervention. Medications are used to intervene with a fever to change the body temperature. Teachers use strategies to change a student's learning outcomes.	Modify is defined as "to alter; to make different in form" … "to change to less extreme" Most often associated with IDEA. Students receiving special education services. Teachers use modifications of grade level standards, strategies, curriculum and assessments to create a learning environment for a specific student
Using grade level curriculum standards via a different path – think differentiated. Adaptations to the regular curriculum to make it possible for the child to be successful at benchmark	Additions to the curriculum to designed to help a student make progress toward benchmarks.	Change in curriculum standards. Change in core program; use of a parallel curriculum that does not include all grade level standards Designates different benchmarks.
Levels the "Playing Field"	Ensures the "Playing Field"	Creates the "Playing Field"
Changes something about the child's environment or services provided. A change that helps a student overcome or work around a learning problem.	Teaches the student a new skill. Teaches the student a strategy to use when applying a skill.	A change in what is being taught to or expected from the student.
Preferential seating	Mini-lessons of skill deficits	Student is involved in the same theme/unit but is provided different tasks/expectations
Shortened assignments	Targeted instruction based on progress monitoring	Individualized materials are provided for student
Peer-tutoring	Additional instruction to students in small groups or individually	Eliminate specific standards
Moving obstacles in a classroom so that a student with a wheelchair could navigate the classroom.	Increase task structure (e.g., directions, rationale, checks for understanding, feedback)	Create individualized benchmarks
Classroom level: seating	Increase opportunities to engage in	

arrangements, note talking, outline/study guides, tape recorders, etc.	active academic responding (e.g., writing, reading aloud, answering questions in class, etc.)	
Repeat/confirm directions	Multi-sensory techniques	
Additional time to complete assignment	Familiar Reading activities for fluency	
Audio tape	Speed sorts of ABCs, sight words	
Reduce the number of items per page or line	Build automaticity with known information, letters, words, phonetic patterns	
Provide a designated reader	Follow up reading with story frame activities: story summary, important ides or plot, setting, character analysis and comparison	
Present instructions orally	Model metacognition	
Allow for verbal responses	Utilize pre-reading strategies and activities: previews, anticipatory guides, and semantic mapping	
Allow for answers to be dictated	Use reciprocal teaching to promote comprehension and comprehension monitoring: predicting, question generating, summarizing and clarifying	
Permit response provided via computer or electronic device	Underline word and phrase clues that lead to making an inference	
Allow frequent breaks	Echo reading: the student imitates the teacher's oral rendition, one sentence or phrase at a time	
Extend allotted time for tests		
Provide a place with minimal distractions		
Administer tests in several sessions		
Administer tests at a specific time		

of day		
Provide special test preparation		

In the 21st century, life and work are conducted in a dynamic context that includes:
• A global society facing complex political, economic, technological, and environmental challenges
• A service economy driven by information, knowledge, and innovation
• Diverse communities and workplaces that rely on cross-cultural collaborative relationships and virtual social networks
• An intensely competitive and constantly changing worldwide marketplace Providing New Jersey students with the life and career skills needed to function optimally within this dynamic context is a critical focus and organizing principle of K-12 public education. New Jersey has both an obligation to prepare its young people to thrive in this environment, and a vested economic interest in grooming an engaged citizenry made up of productive members of a global workforce that rewards innovation, creativity, and adaptation to change.

Mission: 21st-century life and career skills enable students to make informed decisions that prepare them to engage as active citizens in a dynamic global society and to successfully meet the challenges and opportunities of the 21st-century global workplace.

Vision: The systematic integration of 21st-century life and career skills across the K-12 curriculum and in career and technical education programs fosters a population that:
• Applies critical thinking and problem-solving skills to make reasoned decisions at home, in the workplace, and in the global community.
• Uses effective communication, communication technology, and collaboration skills to interact with cultural sensitivity in diverse communities and to work in cross-cultural teams in the multinational workplace.
• Is financially literate and financially responsible at home and in the broader community.
• Demonstrates creative and entrepreneurial thinking by recognizing and acting on promising opportunities while accepting responsibility for possible risks.
• Is knowledgeable about careers and can plan, execute, and alter career goals in response to changing societal and economic conditions.
• Produces community, business, and political leaders who demonstrate core ethical values, including the values of democracy and free enterprise, during interactions with the global community.

Intent and Spirit of the 21st-Century Life and Career Standards
Through instruction in life and career skills, all students acquire the knowledge and skills needed to prepare for life as citizens and workers in the 21st century.
• In Preschool, children's social and emotional development provides the foundation for later learning about careers and life skills (http://www.nj.gov/education/ece/code/expectations/).
• In grades K-5, students are introduced to 21st-century life skills that are critical for personal, academic, and social development. They are also introduced to career awareness information and to basic personal financial literacy skills.
• In grades 6-8, students continue to develop 21st-century life skills and personal financial literacy, while also exploring careers that support their academic and personal interests and aptitudes. As they prepare for the transition to high school, students are provided with opportunities to apply knowledge and skills learned in the classroom to real or simulated career challenges.

• In grades 9-12, students develop increasingly sophisticated 21st-century life skills and personal financial literacy. They engage in the process of career preparation by participating in structured learning experiences, specialized programs, and advanced courses that reflect personal aptitudes and career interests found within one or more of the 16 career clusters developed by the States Career Clusters Initiative.

<u>The Revised Standards</u>
There are four revised 21st-Century Life and Careers standards. Standards 9.1, 9.2, and 9.3 describe life and career skills that are integrated throughout the K-12 curriculum, while Standard 9.4 describes specialized skills that are taught in grades 9-12 as part of career and technical education programs. An overview of the four standards follows.

Standard 9.1 21st-Century Life and Career Skills: All students will demonstrate the creative, critical thinking, collaboration, and problem-solving skills needed to function successfully as both global citizens and workers in diverse ethnic and organizational cultures. Standard 9.1 describes skills that prepare students to fully engage in civic and work life. The standard includes six strands, which reflect the Framework for 21st Century Learning:
• Critical Thinking and Problem Solving
• Creativity and Innovation
• Collaboration, Teamwork, and Leadership
• Cross-Cultural Understanding and Interpersonal Communication
• Communication and Media Fluency
• Accountability, Productivity, and Ethics

Standard 9.2 Personal Financial Literacy: All students will develop skills and strategies that promote personal and financial responsibility related to financial planning, savings, investment, and charitable giving in the global economy. Standard 9.2 describes skills that prepare students for personal and civic financial literacy. The inclusion of Personal Financial Literacy as a standard, rather than as a strand, reflects the growing need for 21stcentury citizens to be financially literate, particularly in light of the increasing number of financial choices they face due to the global economy. Financial literacy includes the application of knowledge, skills, and ethical values when making consumer and financial decisions that impact the self, the family, and the local and global communities. Standard 9.2 is aligned to the Jump $tart Coalition for Personal Financial Literacy’s National Standards in K-12 Personal Finance Education and includes seven strands:
• Income and Careers
• Money Management
• Credit and Debt Management
• Planning, Saving, and Investing
• Becoming a Critical Consumer
• Civic Financial Responsibility
• Risk Management and Insurance

Standard 9.3 Career Awareness, Exploration, and Preparation: All students will apply knowledge about and engage in the process of career awareness, exploration, and preparation in order to navigate the globally competitive work environment of the information age. Standard 9.3 describes skills that prepare

students for career pursuits and lifelong learning. The three strands in Standard 9.3 reflect the requirements outlined in New Jersey Administrative Code (N.J.A.C. 6A:8-3.2):
• Career Awareness (grades K-4)
• Career Exploration (grades 5-8)
• Career Preparation (grades 9-12)

Standard 9.4 Career and Technical Education: All students who complete a career and technical education program will acquire academic and technical skills for careers in emerging and established professions that lead to technical skill proficiency, credentials, certificates, licenses, and/or degrees. Standard 9.4 describes knowledge and skills that prepare students for postsecondary education, training, and employment in a chosen career pathway. Unlike Standards 9.1, 9.2, and 9.3, which apply to all students from grades K-12, Standard 9.4 applies only to high school students enrolled in career and technical education programs.

The adoption of the career and technical education standard reflects the call to action in recent reports by the National Association of State Boards of Education, the National Governors Association, the U.S. Chamber of Commerce, and Achieve regarding the potential of career and technical education, as well as the requirements of the Carl D. Perkins Career and Technical Education Improvement Act of 2006. These documents urge states to adopt policies and practices that effectively integrate academic content standards in career and technical education programs in order to both elevate the role of career and technical education and to align it with postsecondary education and training.

The 16 strands in Standard 9.4 align with the 16 career clusters of the States Career Clusters Initiative. Each strand is further refined to reflect multiple career pathways. By using the clusters as an organizing tool for grouping occupations and careers, Standard 9.4 identifies a common set of knowledge and skills for success within each broad career cluster, as well as for each career pathway within that cluster. This framework has been reviewed nationally by teams of business, industry, labor, education, and higher education representatives to ensure that it encompasses industry-validated knowledge and skills needed for career success.

For each of the 16 career cluster strands, content statements and cumulative progress indicators are provided for the overall career cluster, and additional content statements and cumulative progress indicators are provided for each of the career pathways encompassed by the cluster. Further, each of the 16 overarching career cluster strands is comprised of two types of cumulative progress indicators:
• Cumulative progress indicators for foundational knowledge and skills, which may be taught as part of a variety of academic and/or career and technical education courses.
• Cumulative progress indicators that are specific to the career cluster and/or career pathway under discussion. Two additional resources are provided in connection with Standard 9.4 to support navigation of Standard 9.4 and understanding of career and technical education (CTE) programs:
• The Career Clusters Table describes each of the 16 career clusters and lists the career pathways associated with each cluster.
• More About CTE Programs provides a definition of career and technical education programs and points to information about the development of Standard 9.4.

New Jersey's Technology Standards consist of 8.1 Educational Technology and 8.2 Technology, Engineering, Design and Computational Thinking, which work symbiotically to provide students with the necessary skills for college and career readiness.

"Advances in technology have drastically changed the way we interact with the world and each other. The digital age requires that we understand and are able to harness the power of technology to live and learn". - International Society for Technology in Education

In this ever-changing digital world where citizenship is being re-imagined, our students must be able to harness the power of technology to live, solve problems and learn in college, on the job and throughout their lives. Enabled with digital and civic citizenship skills, students are empowered to be responsible members of today's diverse global society.

Readiness in this century demands that students actively engage in critical thinking, communication, collaboration, and creativity. Technology empowers students with real-world data, tools, experts and global outreach to actively engage in solving meaningful problems in all areas of their lives. The power of technology discretely supports all curricular areas and multiple levels of mastery for all students.

"A major consequence of accelerating technological change is a difference in levels of technological ability and understanding. The workforce of the future must have the ability to use, manage, and understand technology." – International Technology and Engineering Educators Association

The design process builds in our students the recognition that success is not merely identifying a problem but working through a process and that failure is not an end but rather a point for reevaluation. Whether applied as a skill in product development, in the learning environment, in daily life, in a local or more global arena, the design process supports students in their paths to becoming responsible, effective citizens in college, careers and life.

Computational thinking provides an organizational means of approaching life and its tasks. It develops an understanding of technologies and their operations and provides students with the abilities to build and create knowledge and new technologies. Not all students will be programmers, but they should have an understanding of how computational thinking can build knowledge and control technology.

INTERNATIONAL SOCIETY FOR TECHNOLOGY IN EDUCATION (ISTE) STANDARDS

Empowered Learner—Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences.

1a Students articulate and set personal learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process itself to improve learning outcomes.

1b Students build networks and customize their learning environments in ways that support the learning process.

1c Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.

1d Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfertheir knowledge to explore emerging technologies.

Digital Citizen—Students recognize the rights, responsibilities and opportunities of living, learning and working in an interconnected digital world, and they act and model in ways that are safe, legal and ethical.

2a Students cultivate and manage their digital identity and reputation and are aware of the permanence of their actions in the digital world.
2b Students engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices.
2c Students demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property.
2d Students manage their personal data to maintain digital privacy and security and are aware of data-collection technology used to track their navigation online.
<u>Knowledge Constructor</u>—Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.
3a Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.
3b Students evaluate the accuracy, perspective, credibility and relevance of information, media, data or other resources.
3c Students curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
3d Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
<u>Innovative Designer</u>—Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.
4a Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
4b Students select and use digital tools to plan and manage a design process that considers design constraints and calculated risks.
4c Students develop, test and refine prototypes as part of a cyclical design process.
4d Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.
<u>Computational Thinker</u>—Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.
5a Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.
5b Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.
5c Students break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.
5d Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.
<u>Creative Communicator</u>—Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.
6a Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.
6b Students create original works or responsibly repurpose or remix digital resources into new creations.
6c Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

6d Students publish or present content that customizes the message and medium for their intended audiences.
Global Collaborator—Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.
7a Students use digital tools to connect with learners from a variety of backgrounds and cultures, engaging with them in ways that broaden mutual understanding and learning.
7b Students use collaborative technologies to work with others, including peers, experts or community members, to examine issues and problems from multiple viewpoints.
7c Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.
7d Students explore local and global issues and use collaborative technologies to work with others to investigate solutions.

21st CENTURY LIFE & CAREERS—New Jersey Student Learning Standards

Career Ready Practices describe the career-ready skills that all educators in all content areas should seek to develop in their students. They are practices that have been linked to increase college, career, and life success. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study. Each Career Ready Practice includes an overarching statement along with a more detailed description. Below are the 12 overarching statements:
CPR1. Act as a responsible and contributing citizen and employee.

CRP2. Apply appropriate academic and technical skills.

CRP3. Attend to personal health and financial well-being.

CRP4. Communicate clearly and effectively and with reason.

CRP5. Consider the environmental, social and economic impacts of decisions.

CRP6. Demonstrate creativity and innovation.

CRP7. Employ valid and reliable research strategies.

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

CRP9. Model integrity, ethical leadership and effective management.

CRP10. Plan education and career paths aligned to personal goals.

CRP11. Use technology to enhance productivity.

CRP12. Work productively in teams while using cultural global competence.

SCIENCE—NEW JERSEY CORE CURRICULUM CONTENT STANDARDS

5.1.A. Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world.

5.1.12.A.1 Content Statement
Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles.
Cumulative Progress Indicator (CPI) Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.

5.1.12.A.2 Content Statement
Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.
CPI Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.

5.1.12.A.3 Content Statement
Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence.
CPI Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.

5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims.

5.1.12.B.1 Content Statement
Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.
CPI Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data.

5.1.12.B.2 Content Statement
Mathematical tools and technology are used to gather, analyze, and communicate results.
CPI Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.

5.1.12.B.3 Content Statement
Empirical evidence is used to construct and defend arguments.
CPI Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.

5.1.12.B.4 Content Statement
Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.
CPI Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.

5.1.C REFLECT ON SCIENTIFIC KNOWLEDGE: Scientific knowledge builds on itself over time.

5.1.12.C.1 Content Statement
Refinement of understandings, explanations, and models occurs as new evidence is incorporated.
CPI Reflect on and revise understandings as new evidence emerges.

5.1.12.C.2 Content Statement
Data and refined models are used to revise predictions and explanations.
CPI Use data representations and new models to revise predictions and explanations.

5.1.12.C.3 Content Statement
Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges.
CPI Consider alternative theories to interpret and evaluate evidence-based arguments.

5.1.D PARTICIPATE PRODUCTIVELY IN SCIENCE: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms

5.1.12.D.1 Content Statement
Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.
CPI Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.

5.1.12.D.2 Content Statement
Science involves using language, both oral and written, as a tool for making thinking public.
CPI Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.

5.1.12.D.3 Content Statement
Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically.
CPI Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.

5.2 Physical Science All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

5.2.A Properties of Matter: All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia.

5.2.12.A.1 Content Statement
Electrons, protons, and neutrons are parts of the atom and have measurable properties, including mass and, in the case of protons and electrons, charge. The nuclei of atoms are composed of protons and neutrons. A kind of force that is only evident at nuclear distances holds the particles of the nucleus together against the electrical repulsion between the protons.
CPI Use atomic models to predict the behaviors of atoms in interactions.

5.2.12.A.2 Content Statement
Differences in the physical properties of solids, liquids, and gases are explained by the ways in which the atoms, ions, or molecules of the substances are arranged, and by the strength of the forces of attraction between the atoms, ions, or molecules.
CPI Account for the differences in the physical properties of solids, liquids, gases.

5.2.12.A.3 Content Statement
In the Periodic Table, elements are arranged according to the number of protons (the atomic number). This organization illustrates commonality and patterns of physical and chemical properties among the elements.
CPI Predict the placement of unknown elements on the Periodic Table based on their physical and chemical properties..

5.2.12.A.4 Content Statement
In a neutral atom, the positively charged nucleus is surrounded by the same number of negatively charged electrons. Atoms of an element whose nuclei have different numbers of neutrons are called isotopes.
CPI Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes.

5.2.12.A.5 Content Statement
Solids, liquids, and gases may dissolve to form solutions. When combining a solute and solvent to prepare a solution, exceeding a particular concentration of solute will lead to precipitation of the solute from the solution. Dynamic equilibrium occurs in saturated solutions. Concentration of solutions can be calculated in terms of molarity, molality, and percent by mass.
CPI Describe the process by which solutes dissolve in solvents

5.2.12.A.6 Content Statement
Acids and bases are important in numerous chemical processes that occur around us, from industrial to biological processes, from the laboratory to the environment.
CPI Relate the pH scale to the concentrations of various acids and bases

5.2.12.B. Changes in Matter: Substances can undergo physical or chemical changes to form new substances. Each change involves energy.

5.2.12.B.1 Content Statement
An atom's electron configuration, particularly of the outermost electrons, determines how the atom interacts with other atoms. Chemical bonds are the interactions between atoms that hold them together in molecules or between oppositely charged ions
CPI Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form.

5.2.12.B.2 Content Statement
A large number of important reactions involve the transfer of either electrons or hydrogen ions between reacting ions, molecules, or atoms. In other chemical reactions, atoms interact with one another by sharing electrons to create a bond.
CPI Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel.

5.2.12.B.3 Content Statement
The conservation of atoms in chemical reactions leads to the ability to calculate the mass of products and reactants using the mole concept.
CPI Balance chemical equations by applying the law of conservation of mass.

5.2.12.C. Forms of Energy: Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable.

5.2.12.C.1 Content Statement
Gas particles move independently and are far apart relative to each other. The behavior of gases can be explained by the kinetic molecular theory. The kinetic molecular theory can be used to explain the relationship between pressure and volume, volume and temperature, pressure and temperature, and the number of particles in a gas sample. There is a natural tendency for a system to move in the direction of disorder or entropy.
CPI Use the kinetic molecular theory to describe and explain the properties of solids, liquids, and gases.

5.2.12.C.2 Content Statement
Heating increases the energy of the atoms composing elements and the molecules or ions composing compounds. As the kinetic energy of the atoms, molecules, or ions increases, the temperature of the matter increases. Heating a pure solid increases the vibrational energy of its atoms, molecules, or ions. When the vibrational energy of the molecules of a pure substance becomes great enough, the solid melts.
CPI Account for any trends in the melting points and boiling points of various compounds.

5.2.D. Energy Transfer and Conservation: The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one object to another.

5.2.12.D.2 Content Statement
The driving forces of chemical reactions are energy and entropy. Chemical reactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).

CPI Describe the potential commercial applications of exothermic and endothermic reactions.

5.2.12.D.3 Content Statement
Nuclear reactions (fission and fusion) convert very small amounts of matter into energy. CPI Describe the products and potential applications of fission and fusion reactions.

5.2.12.D.4 Content Statement
Energy may be transferred from one object to another during collisions
CPI Measure quantitatively the energy transferred between objects during a collision

5.2.12.D.5 Content Statement
Chemical equilibrium is a dynamic process that is significant in many systems, including biological, ecological, environmental, and geological systems. Chemical reactions occur at different rates. Factors such as temperature, mixing, concentration, particle size, and surface area affect the rates of chemical reactions.
CPI Model the change in rate of a reaction by changing a factor.

STUDENT OUTCOMES

KNOWLEDGE (Information and Concepts) The student will:

1. Design investigations, collect evidence, analyze data, and evaluate evidence to determine causal/correlational relationships and anomalous data. (5.1.12.B.1)
2. Develop an understanding of the relationships among facts, concepts, principles, theories, and models and use these relationships to understand phenomena in the natural world. (5.1.12.A.1)
3. Use tools, evidence, and data to observe, measure, and explain phenomena in the natural world. (5.1.12.A.2)
4. Construct and refine explanations, arguments or models of the natural world through the use of quantitative and qualitative evidence and data. (5.1.12.A.2)
5. Use scientific principles and theories to build and refine standards for data collection, posing controls, and representing evidence. (5.1.12.A.3)
6. Build, refine, and represent evidence-based models using mathematical, physical and computational tools (5.1.12.B.2)
7. Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.(5.1.12.D.3)
8. Reflect on and revise understandings as new evidence emerges. (5.1.12.C.1)
9. Use data representations and new models to revise predictions and explanations. (5.1.12.C.2)
10. Revise predictions and explanations using evidence, and connect explanations/ arguments to established scientific knowledge, models and theories. (5.1.12.B.3)
11. Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (5.1.12.B4)
12. Consider alternative theories to interpret and evaluate evidence-based arguments. (5.1.12.C.3)
13. Engage in multiple forms of discussions in order to process, make sense of, and learn from others' ideas, observations, and experiences. (5.1.12.D.1)
14. Represent ideas using literal representations such as graphs, tables, journals, concept maps, and diagrams. (5.1.12.D.2)

15. Demonstrate either orally or in writing that he/she knows and understands the nature of chemistry as a study of matter, its structure, properties, and the changes it undergoes. (5.2.12.B)
16. Show proficiency in writing chemical formulas, naming compounds, and writing and balancing chemical equations.
17. Demonstrate in writing that he/she can solve problems using critical thinking in such areas as stoichiometry and the gas laws.
18. Communicate, verbally or in writing, a knowledge and understanding of the current atomic theory and of the classification of elements in the periodic table.
19. Explain the periodic trends in specific properties of elements, i.e. ionization energy, electronegativity, electron affinity, atomic and ionic radii using the Periodic Table.
20. Demonstrate a comprehension of the relationship between the type of bonding among atoms and the properties of the compounds formed, i.e. ionic, covalent, and metallic.
21. Demonstrate comprehension of kinetic theory and how energy is involved in the behavior of matter.
22. Show knowledge of chemical equilibrium, reaction rates, reaction mechanisms. acids, bases, and salts.
23. Write lab reports which indicate a comprehension of concepts learned in the classroom and applied in the laboratory.
24. Design experiments to solve a specific problem relating to chemical principles.
25. Build models and name common organic compounds such as hydrocarbons and simple polymers.
26. Distinguish between types of radiation and the energy associated with each
27. Describe the postulates of quantum theory.
28. Predict the products form4ed by common reactants, write and balance equations for the reactions.
29. Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes.
30. Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel
31. Describe the products and potential applications of fission and fusion reactions

ATTITUDES

The student will:

1. Develop an appreciation for the study of chemistry and how it relates to his/her everyday life.
2. Research and investigate possible careers in chemistry.
3. Recognize the impact of chemistry on every aspect of daily life.

SKILLS AND BEHAVIORS

The student will:

1. Demonstrate good problem-solving techniques.
2. Write essays on specific topics in chemistry demonstrating comprehension of a given topic, i.e. the historical development of the Periodic Table, or atomic theory.
3. Demonstrate effective listening and note taking skills in lecture and discussion situations.
4. Demonstrate proper and safe use of laboratory equipment and chemicals during experiments.
5. Use the scientific method in solving laboratory based problems and writing reports based on their solutions.
6. Demonstrate in class discussion and in writing a comprehensive knowledge of chemical technology.
7. Write and balance equations for a variety of chemical reactions.

8. Work cooperatively in small groups to solve problems or perform experiments.
9. Design and interpret graphs using empirical and experimental data.
10. Use spreadsheet and graphing software to report results of laboratory investigations.
11. Design and produce presentations using Power Point presentation software.
12. Set up and perform experiments using computer interfaced sensors to collect data.
13. Use internet search engines to locate chemistry related websites for research and review.
14. be aware of the connection between educational activities and the world of work

STRATEGIES

The following strategies/activities will be used:

NOTE: The suggested activities provided in this document are ideas for the teacher. If the teacher chooses to develop his/her own activity*, it must be of equal or better quality and at the same or higher cognitive levels.*

• Audio visual media
• Charts, handouts, graphs
• Class & individual assignments
• Cooperative activities
• Critical thinking:
• Decision making
• Compare & contrast
• Reliable sources
• Causal explanation
• Prediction
• Debates & panel discussion
• Demonstrations (teacher/student led)
• Direct instruction
• Discussion (teacher/student led)
• Drill practice
• Extra credit project or presentation
• Homework
• Investigation
• Laboratory experiment
• Lecture
• Library and resource documents
• Oral reading
• Periodicals
• Questioning techniques
• Research paper
• Reviews
• Self-instructional instruments
• Textbook: Wilbraham, Chemistry, 2008. Pearson
• Textbook supplements
• Tutoring (peer & teacher)

EVALUATION

NOTE: Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.

Assessments may include

DERIVED ASSESSMENT *inferred from student's ability to respond to items on paper*.

- Tests
- Quizzes
- Homework
- Benchmark assessment

AUTHENTIC ASSESSMENT *based on behavior, product, or outcome*.

- Class participation
- Teacher observation
- Infusion exercises
- Portfolios
- Varied approach projects

PERFORMANCE ASSESSMENT *authentic assessment specific to chemistry*.

- Laboratory

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Chemistry Honors Curriculum

Course Code: SCI—3410 Chemistry Honors
Grade Level: 10th & 11th Grades

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

Developed by Ahmed Khan & the ACHS Curriculum Committee
Reviewed by Science Supervisor.

BOARD OF EDUCATION
ADOPTION DATE: August 2018

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ACKNOWLEDGEMENTS

Administrative Team

Ms. Lina Gil	— Principal (2016)
Dr. Sheree Alexander	— Vice-Principal (2016)
Mr. Stephen Brown	— Vice-Principal (1998)
Mr. Jason Grimes	— Vice-Principal (2017)
Mr. Kendall Williams	— Vice-Principal (2018)

Science Department

Mrs. Dianna Arndt	— Teacher of Secondary Earth & Space Science (2017)
Mrs. Agnes Arsenis	— Teacher of Secondary Physical Science (1991)
Mr. Ephram Bailey	— Teacher of Secondary Biological Science (2009)
Mrs. Regina Banner	— Teacher of Secondary Biological Science (2001)
CWO Christopher Brown	— Teacher of Military Science (2013)
Mrs. Mia Campo	— Teacher of Special Education (Students With Disabilities)(Secondary) (2007)
Mr. Mark Chando	— Teacher of Secondary Biological Science (2004) / Elementary Teacher of Secondary Science (1992)
Mr. Bjorn Christiano	— Teacher of Secondary Biological Science (2007)
Mr. Kevin Corcoran	— Teacher of Secondary Biological Science (2001)
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Dr. John Edmunds, D.C.	— Teacher of Secondary Biological Science (1998)
Mr. Alex Ehrenzeller	— Teacher of Secondary Earth & Space Science (2018)
Mrs. Barbara Hamill	— Teacher of Secondary Physical Science (2001)
Ms. Melanie Jupin	— Special Education (Handicapped)(Secondary) (2006)
Mrs. Courtney Keim	— Teacher of Secondary Physical Science (2006)
Mr. Robert Lamoreux	— Teacher of Secondary Comprehensive Science (2002)
Mr. Frank Manzo	— Teacher of Secondary Biological Science (1992)
Mr. Buddy O'Brien	— Teacher of Secondary Biological Science (2001)
Mr. Christopher Oves	— Teacher of Special Education (Handicapped)(Secondary) (2002)
Mr. William Wineland	— Teacher of Special Education (Students With Disabilities)(Secondary) (2010)

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QSAC STATEMENT OF ASSURANCE (SOA)

August 21, 2017
TO: District Superintendents
District Curriculum Directors/Supervisors
District Board of Education Presidents
FROM: Pamela J. Garozzo PJG Director, County Office Administrative Unit and QSAC
SUBJECT: QSAC Statement of Assurance (SOA)
Instruction and Program #3 – Curriculum Alignment and Adoption Requirements

The purpose of this document is to clarify the requirements for board-adopted, aligned curricula, so that you can provide an accurate response to the QSAC Statement of Assurance (SOA), Instruction and Program indicator #3. As required by N.J.A.C. 6A:8-3.1, all curricula must include:

- **Interdisciplinary connections through the K-12 curriculum;**
- **Integration of 21st century themes and skills; and**
- **Supportive curricula and instructional tools for helping students acquire required knowledge and skills.**

These tools include at a minimum:

- **Pacing guide**
- **List of core instructional materials, including various levels of texts at each grade level**
- **Benchmark assessments**
- **Modifications for special education students, English language learners, students at risk of school failure and gifted students**

Further, all curricula must be aligned to current academic standards. As you know, the New Jersey State Board of Education has adopted academic standards in Visual and Performing Arts, Comprehensive Health and Physical Education, English Language Arts, Mathematics, Science, Social Studies, World Languages, Technology and 21st Century Life and Careers

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PROPOSED NJQSAC DISTRICT PERFORMANCE REVIEW

Since September 2017, science in kindergarten through grade five has been based on the NJSLS-S.

The New Jersey Student Learning Standards for Science (NJSLS-S) are currently the academic target in grades 6-12. The implementation of the standards is only one milestone in a long process of transforming teaching, learning, and assessment necessary for our students to meet the new challenges.

(**Effective July 1, 2018**)

11. Science curriculum and instruction are aligned to the NJSLS in accordance with the Department's curriculum implementation timeline and include the following: (N.J.A.C. 6A:8)

a. Curriculum designed and implemented to meet grade level expectations/graduation requirements;
b. Integrated accommodations and modifications for students with IEPs, 504s, ELLs, and gifted and talented students;
c. Assessments- including benchmarks, formative, summative and alternative assessments;
d. List of core instructional and supplemental materials, including various levels of texts at each grade level;
e. Pacing guide;
f. Interdisciplinary connections;
g. Integration of 21st century skills;
h. Integration of the Technology standard;
i. Integration of the 21st Century Life and Career standards/career counseling.

Ahmed Khan, M.A.I.T.
Teacher of Secondary Physical Science (1992)
Atlantic City High School

Steven Nagiewicz
Teacher of Secondary Earth & Space Science (2008)
Atlantic City High School

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INTRODUCTION

This document is part of a family of resources that are designed to support the transition to the new science standards. Each tool is designed for a specific purpose but they are all grounded the Framework for K-12 Science Education (2012) and the NJSLS-S. The other documents in the family of tools include:

- ***Science Instruction Companion to the Danielson Framework*** **provides science specific indicators for evaluating science instruction;**
- ***NGSS Lesson Screener*** **provides criteria for an informal review (no scoring) of a lesson or short unit's coherence with the NJSLS-S;**
- ***EQuIP Rubric for Lessons and Units: Science*** **provides detailed criteria to measure the degree to which lessons and units are designed for the NJSLS-S;**
- ***Primary Evaluation of Essential Criteria (PEEC)*** **provides criteria to evaluate curriculum materials such as science kits, textbook series, or online programs.**

Table 1: Criteria for an Effective Science Program

A. All Standards, All Students: The science program ensures that ALL students are provided appropriate learning opportunities for ALL of the standards. This includes but is not limited to, students with disabilities, economically disadvantages, English Language Learners, and students who have been identified as gifted. **B. Explaining Phenomena or Designing Solutions: The units focus on supporting students to make sense of engaging and authentic phenomena or design solutions to real-world problem.** **C. Three Dimensional: The units help students develop and use multiple grade- appropriate elements of the science and engineering practices (SEP), disciplinary core ideas (DCI), and crosscutting concepts (CCC), which are deliberately selected to aid student sense-making of phenomena or designing of solutions.** **D. Integrating the Three Dimensions for Instruction and Assessment: The units require student performances that integrate elements of the SEPs, CCCs, and DCIs to make sense of phenomena or design solutions to problems, and the learning tasks elicit student artifacts that show direct, observable evidence of three-dimensional learning.** **E. Relevance and Authenticity: The units motivate student sense-making or problem- solving by taking advantage of student questions and prior experiences in the context of the students' home, neighborhood, and community as appropriate.** **F. Student Ideas: The units provide opportunities for students to express, clarify, justify, interpret, and represent their ideas (i.e., making thinking visible) and to respond to peer and teacher feedback.** **G. Building on Students' Prior Knowledge: The units identify and build on students' prior learning in all three dimensions in a way that is explicit to both the teacher and the students.**

OVERVIEW OF CHEMISTRY

Chemistry introduces the student to the study of matter, its composition and structure, and the changes it may undergo. A study of the structure of the atom combined with the periodic law leads to an understanding of the organization of the elements in the periodic table. This knowledge of the atom and the organization of the elements is used to develop concepts of ionic, covalent and metallic bonding

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among atoms as well as to write formulas for compounds and equations to represent chemical reactions. Phases of matter will be studied and will include an introduction to gas laws, water, aqueous systems and solutions. The course will also incorporate the study of thermochemistry including the concept of heat flow and the relationship between heat and temperature and rates of reaction. Students will be introduced to acids and bases, oxidation and reduction reactions and be able distinguish a fission reaction from a fusion reaction

This course is developed for the student who wishes to have a basic understanding of chemistry as an integral part of the study of nature and as a preparation for advanced science courses. Additionally, an understanding of the scientific process, scientific method, and rational thinking skills is essential for students to sort and evaluate incoming information.

OVERVIEW OF UNITS

Chemistry Model Units

Unit 1: Structure and Properties of Matter **Instructional Days: 30**

In this unit of study, students use investigations, simulations, and models to makes sense of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Students are expected to communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. The crosscutting concepts of *structure and function, patterns, energy and matter*, and *stability and change* are called out as the framework for understanding the disciplinary core ideas. Students use *developing and using models, planning and conducting investigations, using mathematical thinking, and constructing explanations and designing solutions.* Students are also expected to use the science and engineering practices to demonstrate proficiency with the core ideas.

This unit is based on HS-PS1-1, HS-PS1-2, HS-PS1-3, HS-PS2-6, HS-ETS1-3, and HS-ETS1-4.

Unit 2: The Chemistry of Abiotic Systems1 **Instructional Days: 20**

In this unit of study, students *develop and use models, plan and carry out investigations, analyze and interpret data, and engage in argument from evidence to make sense of energy* as a quantitative property of a system—a property that depends on the motion and interactions of matter and radiation within that system. They will also use the findings of investigations to provide a mechanistic explanation for the core idea that total change of energy in any system is always equal to the total energy transferred into or out of the system. Additionally, students develop an understanding that energy, at both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy associated with the configurations (relative positions) of particles.

Students apply their understanding of energy to explain the role that water plays in affecting weather. Students examine the ways that human activities cause feedback that create changes to other systems. Students are expected to demonstrate proficiency in *developing and using models, planning and carrying out investigations, analyzing and interpreting data, engaging in argument from evidence*, and using these practices to demonstrate understanding of core ideas.

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Students also develop possible solutions for major global problems. They begin by breaking these problems into smaller problems that can be tackled with engineering methods. To evaluate potential solutions, students are expected not only to consider a wide range of criteria, but also to recognize that criteria need to be prioritized.
This unit is based on HS-PS3-4, HS-ESS2-5, HS-ESS3-2, and HS-ETS1-3.

Unit 2B: Energy of Chemical Systems[1] **Instructional Days: 20**
Unit 2B is use in a chemistry course when **Unit 2: The Chemistry of Abiotic Systems** is taught in the **Capstone Science Course**. In Energy of Chemical Systems, students will understand energy as a quantitative property of a system—a property that depends on the motion and interactions of matter and radiation within that system. They will also understand that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy, at both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy associated with the configurations (relative positions) of particles.

Students understand the role that water plays in affecting weather. Students can examine the ways that human activities cause feedback that create changes to other systems. Students are expected to demonstrate proficiency *in developing and using models, planning and carrying out investigations, analyzing and interpreting data, engaging in argument from evidence*, and using these practices to demonstrate understanding of core ideas.
This unit is based on HS-PS3-4.

FOOTNOTE: [1] This unit can be taught in either Chemistry or as part of the Capstone Science Course. If this unit is transferred to the Capstone Course, an abbreviated unit on Energy, based on HS—PS3-4, must be provided in its place.

Unit 3: Bonding and Chemical Reactions **Instructional Days: 30**
In this unit of study, students develop and using models, plan and conduct investigations, use mathematical thinking, and construct explanations and design solutions as they develop an understanding of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students also apply an understanding of the process of optimization and engineering design to chemical reaction systems. The crosscutting concepts of patterns, energy and matter, and stability and change are the organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in developing and using models, planning and conducting investigations, using mathematical thinking, and constructing explanations and designing solutions.
This unit is based on HS-PS1-7, HS-PS1-4, HS-PS1-5, HS-PS1-6, and HS-ETS1-2.

Unit 4: Matter and Energy in Living Systems Instructional Days: 20
In this unit of study, students construct explanations for the role of energy in the cycling of matter in organisms. They apply mathematical concepts to develop evidence to support explanations of the interactions of photosynthesis and cellular respiration and develop models to communicate these

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explanations. The crosscutting concept of matter and energy provides students with insights into the structures and processes of organisms.

Students are expected to develop and use models, plan and conduct investigations, use mathematical thinking, and construct explanations and design solutions as they demonstrate proficiency with the disciplinary core ideas.
This unit is based on HS-LS1-7 and HS-LS1-6.

Unit 5: Nuclear Chemistry[2] **Instructional Days: 30**
In this unit of study, energy and matter are studied further by investigating the processes of nuclear fusion and fission that govern the formation, evolution, and workings of the solar system in the universe. Some concepts studied are fundamental to science and demonstrate *scale, proportion, and quantity*, such as understanding how the matter of the world formed during the Big Bang and within the cores of stars over the cycle of their lives.

In addition, an important aspect of Earth and space sciences involves understanding the concept of stability and change while making inferences about events in Earth's history based on a data record that is increasingly incomplete the farther one goes back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record.

The crosscutting concepts of energy and matter; scale, proportion, and quantity; and stability and change are called out as organizing concepts for this unit. Students are expected to demonstrate proficiency in *developing and using models; constructing explanations and designing solutions; using mathematical and computational thinking; and obtaining, evaluating, and communicating information;* and they are expected to use these practices to demonstrate understanding of the core ideas.
This unit is based on HS-PS1-8, HS-ESS1-3, HS-ESS1-1, HS-ESS1-2, and HS-ESS1-6

FOOTNOTE: [2] This unit can be taught in either Chemistry or as part of the Capstone Science Course.

Unit 6: Human Impact: The Chemistry of Sustainability[3] **Instructional Days: 30**
In this unit of study, students use cause and effect to develop models and explanations for the ways that feedbacks among different Earth systems control the appearance of Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface (e.g., volcanism and mountain building), and the sun-driven surface systems that tear down the land through weathering and erosion. Students begin to examine the ways that human activities cause feedbacks that create changes to other systems. Students understand the system interactions that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students model the flow of energy and matter between different components of the weather system and how this affects chemical cycles such as the carbon cycle. Engineering and technology figure prominently here, as students use mathematical thinking and the analysis of geoscience data to examine and construct solutions to the many challenges facing long-term human sustainability on Earth. Here students will use these geoscience data to explain climate change over a wide range of timescales, including over one to ten years: large volcanic eruption, ocean circulation; ten to hundreds of years: changes in human activity, ocean circulation, solar output; tens of thousands to hundreds of thousands of years: changes

to Earth’s orbit and the orientation of its axis; and tens of millions to hundreds of millions of years: long-term changes in atmospheric composition).
This unit is based on HS-ESS2-4, HS-ESS2-6, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, and HS-ETS1-4.

FOOTNOTE: [3] This unit can be taught in either Chemistry or as part of the Capstone Science Course.

Note: The number of instructional days is an estimate based on the information available at this time. 1 day equals approximately 42 minutes of seat time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.

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Unit 1: Structure and Properties of Matter

Instructional Days: 30

This unit is based on HS-PS1-1, HS-PS1-2, HS-PS1-3, HS-PS2-6, HS-ETS1-3, and HS-ETS1-4.

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UNIT 1: Structure and Properties of Matter Instructional Days: 30
How can the substructures of atoms explain the observable properties of substances? ***Why are we so lucky that water has the physical properties that it does?*** ***How do ancient carbon atoms drive economic decisions in the modern world?***
In this unit of study, students use investigations, simulations, and models to makes sense of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Students are expected to communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. The crosscutting concepts of structure and function, patterns, energy and matter, and stability and change are called out as the framework for understanding the disciplinary core ideas. Students will be developing and using models, planning and conducting investigations, using mathematical thinking, and constructing explanations and designing solutions. Students are also expected to use the science and engineering practices to demonstrate proficiency with the core ideas. In this unit of study, students develop and use models, plan and carry out investigations, analyze and interpret data, and engage in argument from evidence to make sense of energy as a quantitative property of a system—a property that depends on the motion and interactions of matter and radiation within that system. They will also use the findings of investigations to provide a mechanistic explanation for the core idea that total change of energy in any system is always equal to the total energy transferred into or out of the system. Additionally, students develop an understanding that energy, at both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy associated with the configurations (relative positions) of particles. Students apply their understanding of energy to explain the role that water plays in affecting weather. Students examine the ways that human activities cause feedback that create changes to other systems. Students are expected to demonstrate proficiency in developing and using models, planning and carrying out investigations, analyzing and interpreting data, engaging in argument from evidence, and using these practices to demonstrate understanding of core ideas. Students also develop possible solutions for major global problems. They begin by breaking these problems into smaller problems that can be tackled with engineering methods. To evaluate potential solutions, students are expected not only to consider a wide range of criteria, but also to recognize that criteria need to be prioritized. This unit is based on HS-PS3-4, HS-ESS2-5, HS-ESS3-2, and HS-ETS1-3.

UNIT 1 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.

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Textbook
<u>Modern Chemistry</u>, Raymond E. Davis Boston: HOLT, RINEHART AND WINSTON (2006).

Core Instructional Materials
- Laptop Cart
- Microsoft office
- CD-Rom Chemistry
- Internet resources
- Virtual Labs

Labs: separating mixtures, density, creating a solution of specific molarity, colligative properties, create a heating/cooling curve, analyzing excel graphs to "discover" periodic trends, metal reactivity lab

Links to Activities:
Energy Forms and Changes : This simulation allows students to investigate thermal energy transfer.
Build an Atom : This simulation allows students to create different illustrations of atoms and provides evidence that protons determine the identity of the element.
Periodic Table Trends : This is a virtual investigation of the periodic trends.
Path to Periodic Table : This investigation provides students with the opportunity to make sense of how and why the periodic table is organized the way that it is. Students will re-create the thought process that Dmitri Mendeleev and Julius Lothar Meyer went through to devise their early periodic tables.
Castle of Mendeleev : Students engage in a fantasy world that requires them to make claims, based on evidence, regarding the identity of unknown materials.
Heating and Cooling Curves : Students evaluate the spacing and energy of particles in different phases.
States of Matter: Illustration of properties of a substance as a solid, liquid and gas.
Periodicity of Elements : Students evaluate the pattern of valence electrons in the periodic table
Intermolecular Forces: Students evaluate how Coulombic Attraction is affected by the number of valence electrons and principal energy levels.
Game: Which element does not belong? : Students look at the period and family to determine which element does not fit in with the others.
Periodic Table Interactive : Useful study tool for all things periodic table.
Building Atoms: Interactive activity where students build atoms by stacking electron orbitals, adding electrons to the orbitals, and viewing how the electron configuration can be used to determine the structure of an atom.

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Atomic and Ionic Structure of the first 12 elements: View the Bohr model and quantum model of the each of the first 12 elements. You can also ionize the atoms to see how the structure would respond.

UNIT 1 Student Learning Objectives INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS & BLUE CODE NUMBERS
Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). *[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]* **(HS-PS3-4)**
Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* *[Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]* **(HS-PS2-6)**
Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. *[Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]* **(HS-PS1-3)**
Suggested labs for this standard: Ask students to design an investigation of physical properties of simple substances. Goal: Students should conclude from their investigation that some substances (i.e. salt and sugar) melt at different temperatures, some freeze at different temperatures, some flow at different rates. Do not discuss ionic and covalent bonding herer, but moreso simply the difference in physical properties. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. *[Clarification Statement: Emphasis is on physical investigations with water and a variety of solid materials. Examples of investigations include solubility, weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]* **(HS-ESS2-5)**
Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. *[Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of*

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metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.] **(HS-PS1-1)**
Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* *[Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]* **(HS-ESS3-2)**
Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. (HS-ETS1-3)
Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. (HS-ETS1-4)

Part A: *How can I use the properties of something (in bulk quantities) to predict what is happening with the subatomic particles?* **CONNECTION TO LESSON PLAN HERE**	
Concepts **INSERT CHAPTER KEY CONCEPTS FROM SUMMARY HERE**	**Formative Assessment** **INSERT CHAPTER OBJECTIVE FROM BOOK SECTION**
• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	*Students who understand the concepts are able to:* • Plan and conduct an investigation individually and collaboratively to produce data that can serve as the basis for evidence for comparing the structure of substances at the bulk scale to infer the strength of electrical forces between particles. In the investigation design, decide on types, how much, and accuracy of data needed to produce reliable measurements; consider limitations on the precision of the data (e.g., number of trials, cost, risk, time); and refine the design accordingly.

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• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	• Use patterns in the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Part B: Does thermal energy always transfer or transform in predictable ways?	
Concepts	**Formative Assessment**
• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Uncontrolled systems always move toward more stable states—that is, toward a more uniform energy distribution. • Although energy cannot be destroyed, it can be converted into less useful forms—for example, to thermal energy in the surrounding environment.	*Students who understand the concepts are able to:* • Plan and conduct an investigation individually or collaboratively to produce data on transfer of thermal energy in a closed system that can serve as a basis for evidence of uniform energy distribution among components of a system when two components of different temperatures are combined. • Use models to describe a system and define its boundaries, initial conditions, inputs, and outputs. • Design an investigation to produce data on transfer of thermal energy in a closed system that can serve as a basis for evidence of uniform energy distribution among components of a system when two components of different temperatures are combined, considering types, how much, and the accuracy of data needed to produce reliable measurements. • Consider the limitations of the precision of the data collected and refine the design accordingly

Part C: *I want to do the right thing, what is the greener choice for grocery bags (paper or plastic/reusable vs. disposable); cold drink containers (plastic, glass, or aluminum); or hot drink containers (paper, Styrofoam, or ceramic)? [Clarification: Students should have the opportunity to select the product and use the Life Cycle Analysis (LCA) to make an evidence-based claim.]*	
Concepts	**Formative Assessment**
	Students who understand the concepts are able to:

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• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, aesthetics, and to consider social, cultural, and environmental impacts. • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. • Models (e.g., physical, mathematical, computer models) can be used to simulate why the molecular-level structure is important in the functioning of designed materials.	• Communicate scientific and technical information about why the molecular - level structure is important in the functioning of designed materials. • Evaluate a solution to a complex real-world problem based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoffs considerations to determine why the molecular level structure is important in the functioning of designed materials. • Use mathematical models and/or computer simulations to show why the molecular level structure is important in the functioning of designed materials. • Communicate scientific and technical information about the attractive and repulsive forces that determine the functioning of the material. • Use mathematical models and/or computer simulations to show the attractive and repulsive forces that determine the functioning of the material. • Examine in detail the properties of designed materials, the structure of the components of designed materials, and the connections of the components to reveal the function. • Use models (e.g., physical, mathematical, computer models) to simulate systems of designed materials and interactions--including energy, matter, and information flows--within and between designed materials at different scales.

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Part D: *What makes water's properties essential to life on our planet? or Why do we look for water on other planets? or What makes water so special?*	
Concepts	**Formative Assessment**
• The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. • The functions and properties of water and water systems can be inferred from the overall structure, the way the components are shaped and used, and the molecular substructure. • These properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks.	*Students who understand the concepts are able to:* • Plan and conduct an investigation individually and collaboratively of the properties of water and its effects on Earth materials and surface processes. • Use models to describe a hydrological system and define its boundaries, initial conditions, inputs, and outputs. • Design an investigation considering the types, how much, and accuracy of data needed to produce reliable measurements. • Consider the limitations on the precision of the data collected and refine the design accordingly.

Part E: *How can a periodic table tell me about the subatomic structure of a substance?*	
Concepts	**Formative Assessment**
• Different patterns may be observed at each of the scales at which a system is studied, and these patterns can provide evidence for causality in explanations of phenomena. • Each atom has a charged substructure. • An atom's nucleus is made of protons and neutrons and is surrounded by electrons.	*Students who understand the concepts are able to:* • Use the periodic table as a model to provide evidence for relative properties of elements at different scales based on the patterns of electrons in the outermost energy level of atoms in main group elements. • Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms in main group elements.

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• The periodic table orders elements horizontally by number of protons in the nucleus of each element’s atoms and places elements with similar chemical properties in columns. • The repeating patterns of this table reflect patterns of outer electron states. • Patterns of electrons in the outermost energy level of atoms can provide evidence for the relative properties of elements at different scales. • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	

Part F: *How can I use the periodic table to predict if I need to duck before mixing two elements?*	
Concepts	**Formative Assessment**
• The periodic table orders elements horizontally by number of protons in the nucleus of each element’s atoms and places elements with similar chemical properties in columns. • The repeating patterns of the periodic table reflect patterns of outer electron states. • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. • Different patterns may be observed at each of the scales at which a system is studied, and these patterns can provide evidence for causality in explanations of phenomena.	Students who understand the concepts are able to: • Use valid and reliable evidence (obtained from students’ own investigations, models, theories, simulations, and peer review) showing the outermost electron states of atoms, trends in the periodic table, and patterns of chemical properties to construct and revise an explanation for the outcome of a simple chemical reaction. • Use the assumption that theories and laws that describe the outcome of simple chemical reactions operate today as they did in the past and will continue to do so in the future. • Observe patterns in the outermost electron states of atoms, trends in the periodic table, and chemical properties.

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	• Use the conservation of atoms and the chemical properties of the elements involved to describe and predict the outcome of a chemical reaction.

UNIT 1 What It Looks Like in the Classroom
In this unit of study, students begin by understanding how the substructure of substances at the bulk scale infers the strength of electrical forces between particles. Students should plan and conduct investigations illustrating how the structure and interactions of matter determine the properties at the bulk amount. These investigations must take into account the accuracy of data required to produce reliable information and consider limitations on the precision of the data. Students should also plan and conduct investigations using attraction and repulsion (charges—cations/anions) at the atomic scale to explain the structure of matter at the bulk scale. For example, students could investigate how the strength of forces between particles is dependent on particle type (ions, atoms, molecules, networked materials [allotropes]). Students should examine crystal structures and amorphous structures. Students could further investigate the role of attraction and repulsion at the atomic scale by investigating melting point and boiling point. Students could plan and conduct an investigation using attraction and repulsion at the atomic scale to explain transformations of matter at the bulk scale—for example, collecting data to create cooling and heating curves. Students might also conduct research projects to compare the structure of substances at the bulk scale and use this research to infer the strength of electrical forces between particles. Information should be gathered from multiple reliable sources and used to support claims. Any data reported should include appropriate units while considering limitations on measurements. In this unit of study, students begin building their understanding of the law of conservation of energy by planning and conducting investigations of thermal energy transfer. Students should investigate and describe a system focusing specifically on thermal energy transfer in a closed system. These investigations will provide opportunities for students to use models that can be made of a variety of materials, such as student-generated drawings and/or digital simulations, such as those available from PhET. These models can be used to describe a system, and define its boundaries, initial conditions, inputs, and outputs.

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Students should have the opportunity to ask and refine questions, using specific textual evidence, about the energy distribution in a system. Students should collect relevant data from several sources, including their own investigations, and synthesize their findings into a coherent understanding.

Using the knowledge that energy cannot be created or destroyed, students should create computational or mathematical models to calculate the change in the energy in one component of a system when the change in energy of the other component(s) and energy flows in and out of the systems are known. In order to do this, students should manipulate variables in specific heat calculations. For example, students can use data collected from simple Styrofoam calorimeters to investigate the mixing of water at different initial temperatures or the adding of objects at different temperatures to water to serve as a basis for evidence of uniform energy distribution among components of a system. Students might conduct an investigation using different materials such as various metals, glass, and rock samples. Using the specific heat values for these substances, students could create mathematical models to represent the energy distribution in a system, identify important quantities in energy distribution, map relationships, and analyze those relationships mathematically to draw conclusions.

These investigations will allow students to collect data to show that energy is transported from one place to another or transferred between systems, and that uncontrolled systems always move toward more stable states with more uniform energy distribution. Students should also observe during investigations that energy can be converted into less useful forms, such as thermal energy released to the surrounding environment. During the design and implementation of investigations, students must consider the precision and accuracy appropriate to limitations on measurement of the data collected and refine their design accordingly.

This unit will also focus on the planning and conducting of mechanical and chemical investigations of water. Properties to be investigated should include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks. This focus is particularly important since water's abundance on Earth's surface, and its unique combination of physical and chemical properties, are central to the planet's dynamics.

In order to understand how the periodic table can be used as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms, students must first understand the idea that atoms have a charged substructure consisting of a nucleus that is composed of protons and neutrons surrounded by electrons. Students should use a variety of models to understand the structure of an atom. Examples may include computer simulations, drawings, and kits. Students can create models of atoms by calculating protons, neutrons, and electrons in any given atom, isotope, or ion.

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In order to understand the predictive power of the periodic table, students should write electron configurations for main group elements, paying attention to patterns of electrons in the outermost energy level. Students should annotate the periodic table to determine its arrangement horizontally by number of protons in the atom's nucleus and its vertical arrangement by the placement of elements with similar chemical properties in columns. Students should also be able to translate information about patterns in the periodic table into words that describe the importance of the outermost electrons in atoms.

✓ Students use the ideas of attraction and repulsion (i.e., charges—cations/anions) at the atomic scale to explain the structure of matter, such as in ion formation, and to explain the properties of matter such as density, luster, melting point, boiling point, etc.

In order to address how the substructure of substances at the bulk scale infers the strength of electrical forces between particles, emphasis should be placed on the importance of outermost electrons in bulk physical properties, bonding, and stability. Students must realize that valence electrons are important.

Students should plan and conduct investigations to show the structure and interactions of matter at the bulk amount. These investigations should illustrate the importance of accurate and reliable data while considering limitations on the precision of the data.

Students should also plan and conduct investigations using attraction and repulsion (charges—cations/anions) at the atomic scale to explain the properties of matter at the bulk scale—for example, investigating melting point, boiling point.

Optional: Students might also conduct research projects to compare the structure of substances at the bulk scale and use this research to infer the strength of electrical forces between particles. Information should be gathered from multiple reliable sources and used to support claims. Any data reported should include appropriate units while considering limitations on measurements.

Suggested Integration of Engineering
In this unit, students consider communicating scientific and technical information about why the molecular level structure is important in the functioning of designed materials. Students evaluate a solution to a complex real-world problem, such as electrically conductive materials made of metal, plastics made of organic polymers, or pharmaceuticals designed for specific biological targets, and then use a computer simulation to model the impact of that solution.

As students consider communicating scientific and technical information about why the molecular-level structure is important in the functioning of designed materials, the focus should be on attractive and repulsive forces. Students might research information about Life Cycle Analysis (LCA), which examines every part of the production, use, and final disposal of a product. LCA requires that students examine

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the inputs (raw materials and energy) required to manufacture products, as well as the outputs (atmospheric emissions, waterborne wastes, solid wastes, coproducts, and other resources). This allows them to make connections between molecular-level structure and product functionality. Students should evaluate the LCA process and communicate a solution to a real-world problem, such as the environmental impact of different types of grocery bags (paper or plastic/reusable vs. disposable), cold drink containers (plastic, glass, or aluminum), or hot drink containers (paper, Styrofoam, or ceramic). They should base their solution to their chosen real-world problem on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Students should then use technology to present a life-cycle-stage model that considers the LCA and typical inputs and outputs measured for their real-world problem. Students need to consider the properties of various materials (e.g. Molar mass, solubility, and bonding) to decide what materials to use for what purposes, inputs and outputs measured for their real-world problem. Students must consider the properties of various materials (e.g. solubility, bonding) to decide which materials to use for which purposes. When students have properties appropriate for the final use, they will be able to consider material uses in LCAs to determine if they are environmentally appropriate.

For further reference, see ChemMatters, (February 2014) “It’s Not Easy Being Green, Or Is It?” at www.acs.org/content/acs/en/education/resources/highschool/chemmatters.html.

To gain a more complete understanding, students might conduct short or more sustained research projects to determine how the properties of water affect Earth materials and surface processes. Once students have an understanding of the conservation of energy and the properties of water that allow it to absorb, store, and release large amounts of energy, the unit will transition to an engineering design problem.

Working from the premise that all forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs, risks, and benefits, students will use cost–benefit ratios to evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources.
For example, students might investigate the real-world technique of using hydraulic fracturing to extract natural gas from shale deposits versus other traditional means of acquiring energy from natural resources. Students will synthesize information from a range of sources into a coherent understanding of competing design solutions for extracting and utilizing energy and mineral resources. As students evaluate competing design solutions, they should consider that new technologies could have deep impacts on society and the environment, including some that were not anticipated. Some of these impacts could raise ethical issues for which science does not provide answers or solutions. In their evaluations, students should make sense of quantities and relationships associated with developing, managing, and utilizing energy and mineral resources. Mathematical models can be used to explain their evaluations. Students might

represent their understanding by conducting a Socratic seminar as a way to present opposing views. Students should consider and discuss decisions about designs in scientific, social, and cultural contexts.

UNIT 1 Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum.
English Language Arts/Literacy • Translate information from the periodic table about the patterns of electrons in the outermost energy level of atoms into words that describe the relative properties of elements. • Evaluate the hypotheses, data, analysis, and conclusions of competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost–benefit ratios, verifying the data when possible and corroborating or challenging conclusions with other design solutions. • Integrate and evaluate multiple design solutions for developing, managing, and utilizing energy and mineral resources based on cost–benefit ratios in order to reveal meaningful patterns and trends. • Evaluate the hypotheses, data, analysis, and conclusions of competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost–benefit ratios, verifying the data when possible and corroborating or challenging conclusions with other design solutions. • Synthesize data from multiple sources of information in order to create data sets that inform design decisions and create a coherent understanding of developing, managing, and utilizing energy and mineral resources. • Cite specific textual evidence comparing the structure of substances at the bulk scale to infer the strength of electrical forces between particles. • Conduct short as well as more sustained research projects to compare the structure of substances at the bulk scale and use this research to infer the strength of electrical forces between particles. • Gather applicable information from multiple reliable sources to support the claim that electrical forces between particles can be used to explain the structure of substances at the bulk scale. • Develop evidence comparing the structure of substances at the bulk scale and the strength of electrical forces between particles.

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Mathematics

• Determine a level of accuracy appropriate to limitations on measurement when reporting quantities representing periodic trends for main group elements based on patterns of electrons in the outermost energy level of atoms.

• Considering the outermost energy level of atoms, define appropriate quantities for descriptive modeling of periodic trends for main group elements based on patterns of electrons in outermost energy levels.

• Determine and interpret the scale and origin in graphs and data displays representing patterns of chemical properties, outer electron states of atoms, trends in the periodic table, and patterns of chemical properties.

• Determine a level of accuracy appropriate to limitations on measurement when reporting quantities of simple chemical reactions.

• Use symbols to represent energy distribution in a system when two components of different temperature are combined, and manipulate the representing symbols. Make sense of quantities and relationships in the energy distribution in a system when two components of different temperature are combined.

• Use a mathematical model to describe energy distribution in a system when two components of different temperature are combined. Identify important quantities in energy distribution in a system when two components of different temperature are combined and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities of the properties of water and their effects on Earth materials and surface processes.

• Use symbols to represent an explanation of the best of multiple design solutions for developing, managing, and utilizing energy and mineral resources and manipulate the representing symbols. Make sense of quantities and relationships in cost–benefit ratios for multiple design solutions for developing, managing, and utilizing energy and mineral resources symbolically and manipulate the representing symbols.

• Use a mathematical model to explain the evaluation of multiple design solutions for developing, managing, and utilizing energy and mineral resources. Identify important quantities in cost–benefit ratios for multiple design solutions for developing, managing, and utilizing

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energy and mineral resources and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

UNIT 1 Modifications for special education students, English language learners, students at risk of school failure and gifted students

Teacher Note: Teachers identify the modifications that they will use in the unit.

• Restructure lessons using Universal Design for Learning (UDL) principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.

• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

• Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).

• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).

• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.

• Use project-based science learning to connect science with observable phenomena.

• Structure the learning around explaining or solving a social or community-based issue.

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• Provide English Language Learners students with multiple literacy strategies.

• Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 1 Research on Student Learning
Students of all ages show a wide range of beliefs about the nature and behavior or particles. They lack an appreciation of the very small size of particles; believe there must be something in the space between particles; have difficulty in appreciating the intrinsic motion of particles in solids, liquids and gases; and have problems in conceptualizing forces between particles (NSDL, 2015).

UNIT 1 Prior Learning

By the end of grade 8, students understand:

Physical science

• Substances are made from different types of atoms, which combine with one another in various ways.

• Atoms form molecules that range in size from two atoms to thousands of atoms.

• Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

• Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.

• In a liquid, the molecules are constantly in contact with others.

• In a gas, the molecules are widely spaced except when they happen to collide.

• In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.

• Solids may be formed from molecules or they may be extended structures with repeating subunits (e.g., crystals).

• The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

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• Substances react chemically in characteristic ways.

• In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

• The total number of each type of atom is conserved, and thus the mass does not change.

• Some chemical reactions release energy, whereas others store energy.

• The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics.

• These physical and chemical properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting point of rocks.

Physical science
Connections to Other Courses
• Each atom has a charged substructure consisting of a nucleus made of protons and neutrons and surrounded by electrons.

• The periodic table orders elements horizontally by the number of protons in the nucleus of each element's atoms and places elements with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

• A stable molecule has less energy than does the same set of atoms separated; at least this much energy is required in order to take the molecule apart.

• Chemical processes, their rates, and whether or not they store or release energy can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.

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• In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.

• The fact that atoms are conserved in chemical reactions, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.

• Energy cannot be created nor destroyed, but it can be transported from one place to another and transferred between systems.

• Mathematical expressions, which quantify how the energy stored in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

• The availability of energy limits what can occur in any system.

• Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).

• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Life Science
• Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

Earth and space science
• The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

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UNIT 1 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.
Physical science- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those elements with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases, the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

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Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

The availability of energy limits what can occur in any system.

Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).

Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Life science-
The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.

As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this

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inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, the ecosystem may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.

Earth and space sciences-
Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.

Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.

The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.

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Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

UNIT 1 Sample of Open Education Resources. Links to Free and Low Cost Instructional Resources
Note- The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials. Energy Forms and Changes: This simulation allows students to investigate thermal energy transfer. Build an Atom: This simulation allows students to create different illustrations of atoms and provides evidence that protons determine the identity of the element. Periodic Table Trends: This is a virtual investigation of the periodic trends. Path to Periodic Table: This investigation provides students with the opportunity to make sense of how and why the periodic table is organized the way that it is. Students will re-create the thought process that Dmitri Mendeleev and Julius Lothar Meyer went through to devise their early periodic tables. Castle of Mendeleev: Students engage in a fantasy world that requires them to make claims, based on evidence, regarding the identity of unknown materials. Heating and Cooling Curves: Students evaluate the spacing and energy of particles in different phases. States of Matter: Illustration of properties of a substance as a solid, liquid and gas. Periodicity of Elements: Students evaluate the pattern of valence electrons in the periodic table. Intermolecular Forces: Students evaluate how Coulombic Attraction is affected by the number of valence electrons and principal energy levels. Game: Which element does not belong? : Students look at the period and family to determine which element does not fit in with the others. Periodic Table Interactive : Useful study tool for all things periodic table. Building Atoms: Interactive activity where students build atoms by stacking electron orbitals, adding electrons to the orbitals, and viewing how the electron configuration can be used to determine the structure of an atom.

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Atomic and Ionic Structure of the first 12 elements: View the Bohr model and quantum model of the each of the first 12 elements. You can also ionize the atoms to see how the structure would respond. • American Association for the Advancement of Science: http://www.aaas.org/programs • American Association of Physics Teachers: http://www.aapt.org/resources/ • American Chemical Society: http://www.acs.org/content/acs/en/education.html • Concord Consortium: Virtual Simulations: http://concord.org/ • International Technology and Engineering Educators Association: http://www.iteaconnect.org/ • National Earth Science Teachers Association: http://www.nestanet.org/php/index.php • National Science Digital Library: https://nsdl.oercommons.org/ • National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx • North American Association for Environmental Education: http://www.naaee.net/ • Phet: Interactive Simulations https://phet.colorado.edu/ • Physics Union Mathematics (PUM): http://pum.rutgers.edu/ • Science NetLinks: http://www.aaas.org/program/science-netlinks

UNIT 1 Appendix A: NGSS and Foundations for the Unit
Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). *[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include*

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mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.] **(HS-PS3-4)**
Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. *[Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]* **(HS-ESS2-5)**
Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. *[Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]* **(HS-PS1-1)**
Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. *[Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point..] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]* **(HS-PS1-3)**
Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. *[Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]* **(HS-PS2-6)**
Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. *[Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]* **(HS-ESS3-2)**
Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. *[Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-3)**

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Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. (HS-ETS1-4)

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education* :

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4) Engaging in Argument from Evidence • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations). (HS-ESS3-2) Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how	PS3.B: Conservation of Energy and Energy Transfer • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-4) • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) PS3.D: Energy in Chemical Processes • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment (HS-PS3-4) ESS3.A: Natural Resources • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)	Systems and System Models • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4) Structure and Function • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5) - *Connections to Engineering, Technology, and Applications of Science* Influence of Science, Engineering, and Technology on Society and the Natural World • Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2)

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much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5) Constructing Explanations and Designing Solutions • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence prioritized criteria, and tradeoff considerations. (HS-ETS1-3) Developing and Using Models • Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)	ETS1.B: Developing Possible Solutions • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary to HS-ESS3-2),(secondary HS-ESS3-4)* ESS2.C: The Roles of Water in Earth's Surface Processes • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5) ETS1.A: Defining and Delimiting Engineering Problems • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed	Influence of Science, Engineering, and Technology on Society and the Natural World • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3) - -- *Connections to Nature of Science* Science Addresses Questions About the Natural and Material World • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2) • Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2) • Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2) --

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Constructing Explanations and Designing Solutions • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3) Obtaining, Evaluating, and Communicating Information • Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) Using Mathematics and Computational Thinking • Use mathematical models and/or computer simulations to predict the	through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) ETS1.B: Developing Possible Solutions • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) ETS1.C: Optimizing the Design Solution • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2) PS1.A: Structure and Properties of Matter • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)	Patterns • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3) Structure and Function • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6) Systems and System Models • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-ETS1-4) - *Connections to Engineering, Technology, and Applications of Science* Influence of Science, Engineering, and Technology on Society and the Natural World New technologies can have deep impacts on society and the environment, including

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effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)	• The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (*secondary to HS-PS2-6*) PS2.B: Types of Interactions • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary to HS-PS1-1),(secondary to HS-PS1-3)* ETS1.B: Developing Possible Solutions• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a	some that were not anticipated Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3)

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	problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)	

UNIT 1 Embedded English Language Arts/Literacy and Mathematics	
English Language Arts/Literacy –	
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS3-4),(HS-ESS3-2) (HS-PS1-3)
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-3)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-2),(HS-PS3-4),(HS-ETS1-3)
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. (HS-PS1-2)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2, (HS-ETS1-3)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation (HS-PS3-4), (HSESS2-5) (HS-PS1-3)
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3) (HS-ETS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4) (HS-PS1-3)(HS-ETS1-3)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest (HS-PS1-4)
Mathematics –	
MP.2	Reason abstractly and quantitatively. (HS-PS3-4),(HS-ESS3-2),(HS-ETS1-3) (HS-ETS1-4)
MP.4	Model with mathematics. (HS-PS3-4), (HS-ETS1-3) (HS-ETS1-4)

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HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2), (HS-PS1-3)

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Unit 2: The Chemistry of Abiotic Systems1

Instructional Days: 30

This unit is based on HS-PS3-4, HS-ESS2-5, HS-ESS3-2, and HS-ETS1-3.

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UNIT 2: The Chemistry of Abiotic Systems	Instructional Days: 30

How can one explain the structure, properties, and interactions of matter?
How do organisms obtain and use the energy they need to live and grow?

In this unit of study, students will develop and use models, plan and conduct investigations, use mathematical thinking, and construct explanations and design solutions as they develop an understanding of the substructure of atoms while providing more mechanistic explanations of the properties of substances. Chemical reactions can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students also apply an understanding of the process of optimization and engineering design to chemical reaction systems. Students will also construct explanations for the role of energy in the cycling of matter in organisms. They apply mathematical concepts to develop evidence to support explanations of the interactions of photosynthesis and cellular respiration and develop models to communicate these explanations. The crosscutting concept of matter and energy provides students with insights into the structures and processes of organisms. Students are expected to develop and use models, plan and conduct investigations, use mathematical thinking, and construct explanations and design solutions as they demonstrate proficiency with the disciplinary core ideas. The crosscutting concepts of patterns, energy and matter, and stability and change are the organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in developing and using models, planning and conducting investigations, using mathematical thinking, and constructing explanations and designing solutions.

UNIT 2 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.

Textbook

Modern Chemistry, Raymond E. Davis Boston: HOLT, RINEHART AND WINSTON (2006).

Core Instructional Materials

- Laptop Cart
- Microsoft office
- CD-Rom Chemistry
- Internet resources
- Virtual Labs

Labs: Chemical Changes, Types of Reactions, Chemical/Physical Changes Lab,
Stoichiometry of Magnesium Oxide, Synthesis of Sodium Chloride, Mole-Mass Relationship,
Conservation of Mass

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Links to Activities: Ionic Bonding Interactive Game: Students fit together cations and anions to create ionic compounds. Molecular Geometry : Students evaluate how the number of bonds and lone pairs of electrons determine the shape of a molecule. Types of Chemical Reactions : Students apply the analogy of dancing to identify different types of reactions. Balancing Chemical Reactions: Students demonstrate how to balance a chemical equation.

UNIT 2 Student Learning Objectives **INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS & BLUE CODE NUMBERS**
Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. *[Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]* (**HS-PS1-2**)
Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. *[Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]* (**HS-PS1-7**)
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. *[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]* **(HS-LS1-5)**
Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. *[Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]* (**HS-LS1-7**)
Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. *[Clarification Statement: Emphasis is on using evidence*

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from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.] (HS-LS1-6)
Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. *[Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples].* (HS-ETS1-3)

UNIT 2 Quick Links		
Unit Sequence p. 2	Research on Learning p.	Sample Open Education Resources p.
What it Looks Like in the Classroom p.	Prior Learning p.	References p.
Connecting with Ela/literacy and Math p.	Connections to Other Courses p.	Appendix A: NGSS and Foundations p.
Modifications p.		

Part A: *How can I use the periodic table to predict if I need to duck before mixing two elements?* **CONNECTION TO LESSON PLAN HERE**	
Concepts **INSERT CHAPTER KEY CONCEPTS FROM SUMMARY HERE**	**Formative Assessment** **INSERT CHAPTER OBJECTIVE FROM BOOK SECTION**
• The fact that atoms are conserved together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. • Different patterns may be observed at each of the scales at which a system is studied, and these patterns can provide evidence for causality in explanations of phenomena.	*Students who understand the concepts are able to:* • Use valid and reliable evidence (obtained from students' own investigations, models, theories, simulations, and peer review) showing the outermost electron states of atoms, trends in the periodic table, and patterns of chemical properties to construct and revise an explanation for the outcome of a simple chemical reaction. • Use the assumption that theories and laws that describe the outcome of simple chemical reactions operate today as they did in the past and will continue to do so in the future. • Observe patterns in the outermost electron states of atoms and trends in the periodic table

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	• Use the conservation of atoms and the chemical properties of the elements involved to describe and predict the outcome of a chemical reaction.

Part B: *Where do the atoms go during a chemical reaction?*	
Concepts	**Formative Assessment**
• The fact that atoms are conserved, together with the knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. • The total amount of matter in closed systems is conserved. • The total amount of matter in a chemical reaction system is conserved. • Changes of matter in a system can be described in terms of how matter flows into, out of, and within that system. • Changes of matter in a chemical reaction system can be described in terms of matter flows into, out of, and within that system.	*Students who understand the concepts are able to:* • Use mathematical representations of chemical reaction systems to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. • Use mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and products and the translation of these relationships to the macroscopic scale, using the mole as the conversion from the atomic to the macroscopic scale. • Use the fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, to describe and predict chemical reactions. • Describe changes of matter in a chemical reaction system in terms of matter flows into, out of, and within that system.

Part C: *How do photosynthesis and cellular respiration result in the formation of new compounds?*	
Concepts	**Formative Assessment**
• The process of photosynthesis converts light energy to glucose by converting carbon dioxide plus water into sugars plus released oxygen.	*Students who understand the concepts are able to:* • Provide a mechanistic explanation for how photosynthesis transforms light energy into glucose.

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• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. • Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.	• Use their understanding of conservation of matter to illustrate the inputs and outputs of matter, and the transformation of energy from light to glucose in photosynthesis. • Construct an evidence-based model, to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed.

Part D: *How do elements of a sugar molecule combine with other elements and what molecules are formed?*	
Concepts	**Formative Assessment**
• Sugar molecules contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. • As matter flows through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • Changes of matter in a system can be described in terms of matter flowing into, out of, and within that system.	*Students who understand the concepts are able to:* • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules. • Construct and revise an explanation, based on valid and reliable evidence from a variety of sources (including models, theories, simulations, peer review) and on the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon based molecules.

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	• Use evidence from models and simulations to support explanations for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.

UNIT 2 What It Looks Like in the Classroom
In unit 2, students will use their understanding of atomic structure and periodic trends to describe and predict chemical reactions, and the conservations of mass within a system. Students will understand that the total amount of matter in a closed system (including chemical reaction systems) is conserved. Changes of energy and matter in the system can be described in terms of how energy and matter flow into, out of, and within that system. Using this knowledge, and knowledge of the chemical properties of elements, students should be able to describe and predict simple chemical reactions in terms of mass and conversion of kinetic to stored energy. The mole concept and stoichiometry are used to show proportional relationships between masses of reactants and products. Students should be able to use balanced equations to show mass relationships between reactants and products. Students should also gain an understanding of the use of dimensional analysis to perform mass to mole conversions that demonstrate how mass is conserved during chemical reactions. Focus should be on students' use of mathematics to demonstrate their thinking about proportional relationships among masses of reactants and products and to make connections between the atomic and macroscopic world. Students should use units appropriately and consistently, considering limitations on measurement, for the purpose of descriptive modeling of the proportional relationships between masses of atoms in the reactants and products and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. To explain the outcomes of chemical reactions using the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties, students should use investigations, simulations, and models of chemical reactions to prove that atoms are conserved. For example, students might observe simple reactions in a closed system and measure the mass before and after the reaction as well as count atoms in reactants and products in chemical formulas. Students should also construct chemical formulas involving main group elements in order to model that atoms are conserved in chemical reactions (the Law of Conservation of Mass). Students need to describe and predict simple chemical reactions, including combustion, involving main group elements. Students should use units when modeling the outcome of chemical reactions. When reporting quantities, students should choose a level of accuracy appropriate to limitations on measurement. Students should also be able to write a rigorous explanation of the outcome of simple chemical reactions, using data from their own investigations, models, theories, and simulations. They should strengthen their explanations by drawing and citing evidence from informational text.

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✓ Students also use the ideas of attraction and repulsion (charges—cations/anions) at the atomic scale to explain transformations of matter—for example, reaction with oxygen, reactivity of metals, types of bonds formed, and number of bonds formed. Students will explain bonding through the patterns in outermost electrons, periodic trends, and chemical properties.

This unit of study continues to build will also approach the content from a life science standpoint. Students will use their understanding of chemical reactions and the conservation of matter to support their learning as they model photosynthesis and cellular respiration. Work with chemical reactions will help students develop explanations for the formation of amino acids and other large, carbon-based molecules. Also, students continue developing and using models, constructing explanations and designing solutions, and obtaining, evaluating, and communicating information.

In particular, both photosynthesis and cellular respiration will be the reactions used to emphasize that the reactants (inputs) and products (outputs) show the transfer of matter from one system of interacting molecules to another. In developing models to represent how photosynthesis transforms light energy into stored chemical energy (glucose) and the inputs and outputs of cellular respiration, students might use digital media in presentations to enhance understanding. *[Clarification, The focus of this unit is on the basic inputs and outputs of these processes. The specific biological steps of the Calvin cycle, Glycolysis, and Kreb cycle are not the focus this unit]*. In photosynthesis, light energy is converted to stored energy when carbon dioxide and water are converted into sugars. Oxygen is released in this process. The organism then converts the chemical energy (glucose) into a usable form (A.T.P) on the cellular level through the process of cellular respiration.

At the same time, students take an in-depth look at the polymerization of sugar; they should research and investigate how simple sugars (made from carbon, hydrogen, and oxygen) are combined and recombined in different structures with specific functions. Students will construct and revise explanations for how simple sugars help form hydrocarbon backbones (amino acids) or carbon-based backbones (protein, DNA, new organism). Explanations should be supported and revised using evidence from multiple sources of text, models, theories, simulations, students' own investigations, and peer review. Students' explanations should describe the formation of amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA) that can be used, for example, to form new cells. It is important to remember that students are only required to conceptually understand the process, not the specific chemical reactions or the identification of macromolecules such as amino acids and DNA.

UNIT 2 Connecting with English Language Arts/Literacy and Mathematics
English Language Arts/Literacy • Write an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties of elements using well-chosen, relevant, and sufficient facts; extended definitions; and concrete details from students' own investigations, models, theories, simulations, and peer review.

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• Develop and strengthen explanations for the outcome of a simple chemical reaction by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties of elements.

• Draw evidence from informational texts about the outermost electron states of atoms, trends in the periodic table, and patterns of chemical properties of elements to construct a rigorous explanation of the outcome of a simple chemical reaction.

• Make strategic use of digital media in presentations to enhance understanding of how photosynthesis transforms light energy into stored chemical energy.

• Use digital media in presentations to enhance understanding of the inputs and outputs of the process of cellular respiration.

• Cite specific textual evidence to support how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.

• Use evidence from multiple sources to clearly communicate an explanation for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.

• Revise an explanation for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant.

• Draw evidence from informational texts to describe how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.

Mathematics

• Use units as a way to understand the outcome of a simple chemical reaction involving main group elements based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. Choose and interpret units consistently in chemical reactions.

• Determine a level of accuracy appropriate to limitations on measurement when reporting quantities of simple chemical reactions.

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• Represent an explanation that atoms, and therefore mass, are conserved during a chemical reaction symbolically and manipulate the representing symbols. Make sense of quantities and relationships about the conservation of atoms and mass during chemical reactions symbolically and manipulate the representing symbols. • Use units as a way to understand the conservation of atoms and mass during chemical reactions; choose and interpret units consistently in formulas representing proportional relationships between masses of atoms in the reactants and products and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale; choose and interpret the scale and origin in graphs and data displays representing the conservation of atoms and mass in chemical reactions. • Define appropriate quantities for the purpose of descriptive modeling of the proportional relationships between masses of atoms in the reactants and products and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. • Choose a level of accuracy appropriate to limitations on measurement when reporting quantities representing proportional relationships between masses of atoms in the reactants and products and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale.

UNIT 2 Modifications
Teacher Note: Teachers identify the modifications that they will use in the unit. • Restructure lesson using Universal Design for Learning principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue.

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• Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 2 Research on Student Learning
Middle- and high-school student thinking about chemical change tends to be dominated by the obvious features of the change. For example, some students think that when something is burned in a closed container, it will weigh more because they see the smoke that was produced. Further, many students do not view chemical changes as interactions. They do not understand that substances can be formed by the recombination of atoms in the original substances. Rather, they see chemical change as the result of a separate change in the original substance, or changes, each one separate, in several original substances. For example, some students see the smoke formed when wood burns as having been driven out of the wood by the flame (**NSDL, 2015**).

UNIT 2 Prior Learning
Physical science • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change. • Some chemical reactions release energy, others store energy. *Life science* • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

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• Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.
• Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
• Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

UNIT 2 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.
Physical science • Substances are made from different types of atoms, which combine with one another in various ways. • Atoms form molecules that range in size from two to thousands of atoms. • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change. • Some chemical reactions release energy, others store energy. *Life science* • The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. • The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

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• Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.
• Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

UNIT 2 Sample of Open Education Resources. Links to Free and Low Cost Instructional Resources

Note- The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials.

• American Association for the Advancement of Science: http://www.aaas.org/programs

• American Chemical Society: http://www.acs.org/content/acs/en/education.html

• Concord Consortium: Virtual Simulations: http://concord.org/

• International Technology and Engineering Educators Association: http://www.iteaconnect.org/

• National Earth Science Teachers Association: http://www.nestanet.org/php/index.php

• National Science Digital Library: https://nsdl.oercommons.org/

• National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx

• North American Association for Environmental Education: http://www.naaee.net/

• Phet: Interactive Simulations https://phet.colorado.edu/

• Science NetLinks: http://www.aaas.org/program/science-netlinks

• Ionic Bonding Interactive Game: Students fit together cations and anions to create ionic compounds.

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• Molecular Geometry: Students evaluate how the number of bonds and lone pairs of electrons determine the shape of a molecule. • Types of Chemical Reactions: Students apply the analogy of dancing to identify different types of reactions. • Balancing Chemical Reactions: Students demonstrate how to balance a chemical equation.

UNIT 2 Appendix A: NGSS and Foundations for the Unit
Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. *[Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]* (**HS-PS1-2**)
Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. *[Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]* (**HS-PS1-7**)
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. *[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]* (**HS-LS1-5**)
Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. *[Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]* (**HS-LS1-7**)
Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. *[Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.]* (**HS-LS1-6**)
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (**HS-ETS1-2**)

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The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models • Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-5),(HS-LS1-7) Constructing Explanations and Designing Solutions • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-6)	PS1.B: Chemical Reactions • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2) ESS2.D: Weather and Climate • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) ETS1.B: Developing Possible Solutions • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)	Energy and Matter • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6) • Energy cannot be created nor destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS1-7)

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	• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) ETS1.C: Optimizing the Design Solution • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (secondary to HS-PS1-6) ETS1.A: Defining and Delimiting Engineering Problems • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)	

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	LS1.A: Structure and Function • Systems of specialized cells within organisms help them perform the essential functions of life. (secondary to HS-LS1-4, HS-LS1-5, HS-LS1-6) • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (secondary to HS-LS1-4, HS-LS1-5, HS-LS1-6) • Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (secondary to HS-LS1-4, HS-LS1-5, HS-LS1-6) • Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (secondary to HS-LS1-4, HS-LS1-5, HS-LS1-6) ETS1.B: Developing Possible Solutions • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and	

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	aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) ETS1.C: Optimizing the Design Solution • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2) LS1.B: Growth and Development of Organisms • In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that	

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	work together to meet the needs of the whole organism. (HS-LS1-4) LS1.C: Organization for Matter and Energy Flow in Organisms • The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5) • The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HS-LS1-6) • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7) • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite	

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	ongoing energy transfer to the surrounding environment. (HS-LS1-7)	

UNIT 2 Embedded English Language Arts/Literacy and Mathematics Standards

English Language Arts/Literacy

RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS1-6)
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-5) (HS-LS1-6)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection and research (HS-LS1-6)
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1),(HS-ETS1-3)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-5)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-6)

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Unit 3: Energy of Chemical Systems
Instructional Days: 20

1 This unit can be taught in either Chemistry or as part of the Capstone Science Course. If this unit is transferred to the Capstone Course, an abbreviated unit on Energy, based on HS—PS3-4, must be provided in its place.

This unit is based on HS-PS1-4.

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UNIT 3 Energy in Chemical Systems	Instructional Days: 20

How is energy transferred within a system?
How do organisms obtain and use the energy they need to live and grow?

Students will understand energy as a quantitative property of a system—a property that depends on the motion and interactions of matter and radiation within that system. They will also understand that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy, at both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy associated with the configurations (relative positions) of particles.

In this unit of study, students develop and using models, plan and conduct investigations, use mathematical thinking, and construct explanations and design solutions as they develop an understanding of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students also apply an understanding of the process of optimization and engineering design to chemical reaction systems. The crosscutting concepts of patterns, energy and matter, and stability and change are the organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in developing and using models, planning and conducting investigations, using mathematical thinking, and constructing explanations and designing solutions.

UNIT 3 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.

Textbook
Modern Chemistry, Raymond E. Davis Boston: HOLT, RINEHART AND WINSTON (2006).

Core Instructional Materials
- Laptop Cart
- Microsoft office
- CD-Rom Chemistry
- Internet resources
- Virtual Labs

Labs: Chemical Changes, Types of Reactions, Chemical/Physical Changes Lab, Stoichiometry of Magnesium Oxide, Synthesis of Sodium Chloride, Mole-Mass Relationship, Conservation of Mass

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Links to Activities:
Ionic Bonding Interactive Game: Students fit together cations and anions to create ionic compounds.

Molecular Geometry : Students evaluate how the number of bonds and lone pairs of electrons determine the shape of a molecule.

Types of Chemical Reactions : Students apply the analogy of dancing to identify different types of reactions.

Balancing Chemical Reactions: Students demonstrate how to balance a chemical equation.

UNIT 3 Student Learning Objectives INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS & CODE NUMBERS
Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. *[Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]* **(HS-PS1-4)**
Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. *[Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]* **(HS-PS1-5)**
Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. *[Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]* **(HS-PS1-6)**
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. *[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]* **(HS-LS1-5)**

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Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. *[Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]* **(HS-LS1-7)**

Part A: *Does thermal energy always transfer or transform in predictable ways?* **CONNECTION TO LESSON PLAN HERE**	
Concepts **INSERT CHAPTER KEY CONCEPTS FROM SUMMARY HERE**	**Formative Assessment** **INSERT CHAPTER OBJECTIVE FROM BOOK SECTION**
• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Uncontrolled systems always move toward more stable states—that is, toward a more uniform energy distribution. • Although energy cannot be destroyed, it can be converted into less useful forms—for example, to thermal energy in the surrounding environment.	*Students who understand the concepts are able to:* • Plan and conduct an investigation individually or collaboratively to produce data on transfer of thermal energy in a closed system that can serve as a basis for evidence of uniform energy distribution among components of a system when two components of different temperatures are combined. • Use models to describe a system and define its boundaries, initial conditions, inputs, and outputs. • Design an investigation to produce data on transfer of thermal energy in a closed system that can serve as a basis for evidence of uniform energy distribution among components of a system when two components of different temperatures are combined, considering types, how much, and the accuracy of data needed to produce reliable measurements. • Consider the limitations of the precision of the data collected and refine the design accordingly

Part B: *How does energy flow in a chemical reaction?*	
Concepts	**Formative Assessment**
• The total amount of energy in closed systems is conserved.	*Students who understand the concepts are able to:*

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• The total amount of energy in a chemical reaction system is conserved. • Changes of energy in a system can be described in terms of how energy flows into, out of, and within that system. • Changes of energy in a chemical reaction system can be described in terms of how energy flows into, out of, and within that system.	• Use the fact that energy is conserved to describe and predict energy flow in chemical reactions. • Describe changes of energy and matter in a chemical reaction system in terms of how energy flows into, out of, and within that system.

Part C: *What is different inside a heat pack and a cold pack?*	
Concepts	**Formative Assessment**
 • A stable molecule has less energy than the same set of atoms separated; at least this much energy must be provided in order to take the molecule apart. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Changes of energy and matter in a chemical reaction system can be described in terms of collisions of molecules and the rearrangements of atoms into new molecules, with subsequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	*Students who understand the concepts are able to:* • Explain the idea that a stable molecule has less energy than the same set of atoms separated. • Describe changes of energy and matter in a chemical reaction system in terms of energy and matter flows into, out of, and within that system. • Describe chemical processes, their rates, and whether or not they store or release energy in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. • Develop a model based on evidence to illustrate the relationship between the release or absorption of energy from a chemical reaction system and the changes in total bond energy.

Part D: *Is it possible to change the rate of a reaction or cause two elements to react that do not normally want to?*	
Concepts	**Formative Assessment**

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• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Patterns in the effects of changing the temperature or concentration of the reacting particles can be used to provide evidence for causality in the rate at which a reaction occurs.	*Students who understand the concepts are able to:* • Use the number and energy of collisions between molecules (particles) to explain the effects of changing the temperature or concentration of the reacting articles on the rate at which a reaction occurs. • Use patterns in the effects of changing the temperature or concentration of the reactant particles to provide evidence for causality in the rate at which a reaction occurs. • Apply scientific principles and multiple and independent student-generated sources of evidence to provide an explanation of the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Part E: *What can we do to make the products of a reaction stable?*	
Concepts	**Formative Assessment**
• Much of science deals with constructing explanations of how things change and how they remain stable. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others may be needed. • Explanations can be constructed explaining how chemical reaction systems can change and remain stable.	*Students who understand the concepts are able to:* • Construct explanations for how chemical reaction systems change and how they remain stable. • Design a solution to specify a change in conditions that would produce increased amounts of products at equilibrium in a chemical system based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. • Break down and prioritize criteria for increasing amounts of products in a chemical system at equilibrium.

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	• Refine the design of a solution to specify a change in conditions that would produce increased amounts of products at equilibrium in a chemical system based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Part F: *How do photosynthesis and cellular respiration result in a net transfer of energy?*	
Concepts	**Formative Assessment**
• The process of photosynthesis converts light energy to stored energy by converting carbon dioxide plus water into sugars plus released oxygen. • Changes of energy in a system can be described in terms of how energy flows into, out of, and within a system. • As energy flows through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. • Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. • Energy cannot be created nor destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.	*Students who understand the concepts are able to:* • Provide a mechanistic explanation for how photosynthesis transforms light energy into stored chemical energy. • Use their understanding of energy flow and conservation of energy to illustrate the inputs and outputs of matter and the transformation of energy in photosynthesis. • Construct an evidence-based model, to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy. • Use their understanding of energy flow and conservation of energy to illustrate the inputs and outputs of the process of cellular respiration.

UNIT 3 What It Looks Like in the Classroom

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This unit of study looks at energy flow and matter but with emphasis on photosynthesis, cellular respiration, and polymerization. Students should use models such as diagrams, chemical equations, and conceptual models to illustrate how matter and energy flow through different organizational levels of living systems, from microscale to macroscale.

Models should use evidence to illustrate how photosynthesis transforms light energy into stored chemical energy; how cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy; and to illustrate the inputs and outputs of matter and the transformations of energy in both processes. Models could include chemical equations, flow diagrams, manipulatives, and conceptual models. Models should also illustrate that energy cannot be created or destroyed, and that it moves only between one place and another, between objects, or between systems.

This unit also expands student understanding of the conservation of energy within a system by emphasizing the key idea that a stable molecule has less energy than the same set of atoms when separated. To support this concept, students might look at the change in energy when bonds are made and broken in a reaction system. Students might also analyze molecular-level drawings and tables showing energies in compounds with multiple bonds to show that energy is conserved in a chemical reaction.

In addition to conservation of energy, students should explore energy flow into, out of, and within systems (including chemical reaction systems). Students might be given data and asked to graph the relative energies of reactants and products to determine whether energy is released or absorbed. They should also conduct simple chemical reactions that allow them to apply the law of conservation of energy by collecting data from their own investigations. Students should be able to determine whether reactions are endothermic and exothermic, constructing explanations in terms of energy changes. These experiences will allow them to develop a model that relates energy flow to changes in total bond energy. Examples of models might include molecular-level drawings, energy diagrams, and graphs.

Students should expand their study of bond energies by relating this concept to kinetic energy. This can be understood in terms of the collisions of molecules and the rearrangement of atoms into new molecules as a function of their kinetic energy content. Students should also study the effect on reaction rates of changing the temperature and/or concentration of a reactant (Le Chatelier’s principle). Students might explore the concept of equilibrium through investigations, which may include manipulations of variables such as temperature and concentration. Examples of these investigations may include the iodine clock reaction, the ferrous cyanide complex, as well as computer simulations such as those located at www.harpercollege.edu/tm-ps/chm/100/dgodambe/thedisk/equil/equil.htm. Using results from these investigations, students should develop an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs and on equilibrium. Students should be able cite evidence from text to support their explanations after conducting research.

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Finally, in order to meet the engineering requirement for Unit 3, students should design a solution to specify a change in conditions that would produce increased amounts of products at equilibrium. As they consider their design, students should keep in mind that much of science deals with constructing explanations for how things change and how they remain stable. Through investigations and practice in changing reaction conditions (as mentioned above), as well as through teacher demonstrations such as MOM to the Rescue/Acid–Base Reaction (Flinn Scientific), students should come to understand that in many situations, a dynamic and condition dependent balance between a reaction and the reverse reaction determines the number of all types of molecules present. Examples of designs that students could refine might include different ways to increase product formation. Designs should include methods such as adding reactants or removing products as a means to change equilibrium. Students will base these design solutions on scientific knowledge, student-generated sources of evidence from prior investigations, prioritized criteria, and tradeoff considerations. They will do this in order to produce the greatest amount of product from a reaction system.

Integration of engineering -
The engineering performance expectation HS-PS1-1 calls specifically for a connection to HS-ETS1.C. To meet this requirement, HS-ETS1-2 has been identified as appropriate for this unit, since it directs students to design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. Students will design a solution to specify a change in conditions that would produce increased amounts of products at equilibrium.

UNIT 3 Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum.
English Language Arts/Literacy • Make strategic use of digital media in presentations to enhance understanding of how photosynthesis transforms light energy into stored chemical energy. • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations showing that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy to enhance understanding of findings, reasoning, and evidence and to add interest. • Cite specific textual evidence to support the concept that changing the temperature or concentration of the reacting particles affects the rate at which a reaction occurs. • Develop an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples.

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• Construct short as well as more sustained research projects to answer how to increase amounts of products at equilibrium in a chemical system. Synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Mathematics

• Use a mathematical model to explain how the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy, and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Represent an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs symbolically and manipulate the representing symbols. Make sense of quantities and relationships about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs symbolically and manipulate the representing symbols.

• Use units as a way to understand an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. Choose and interpret units consistently in formulas representing the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. Choose and interpret the scale and the origin in graphs and data displays representing the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities representing the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

• Use a mathematical model to explain how to increase amounts of products at equilibrium in a chemical system. Identify important quantities in the cycling of matter and flow of energy among organisms in an ecosystem, and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

UNIT 3 Modifications for special education students, English language learners, students at risk of school failure and gifted students
Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.

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• Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 3 Research on Student Learning
Students' meaning for "energy" both before and after traditional instruction is considerably different from its scientific meaning. In particular, students believe energy is associated only with humans or movement, is a fuel-like quantity which is used up, or is something that makes things happen and is expended in the process. Students rarely think energy is measurable and quantifiable. Students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy change focus only on forms that have perceivable effects. The transformation of motion to heat seems to be difficult for students to accept, especially in cases with no obvious temperature increase. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen. Some students of all ages have difficulty in identifying the sources of energy for plants and also for animals. Students tend to confuse energy and other concepts such as food, force, and temperature. As a result, students may not appreciate the uniqueness and importance of energy conversion processes like respiration and photosynthesis. Although specially designed instruction does help students correct their understanding about energy exchanges, some difficulties remain. [10] Careful coordination between The Physical Setting and The

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Living Environment benchmarks about conservation of matter and energy and the nature of energy may help alleviate these difficulties (NSDL, 2015).

UNIT 3 Prior Learning
Physical science • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). • The changes of state that occur with variations in temperature or pressure can be described and predicted using models of matter. Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change. Some chemical reactions release energy; others store energy. • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. • Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object or a ball, respectively). • Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. • A system of objects may also contain stored (potential) energy, depending on their relative positions.

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• Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

• When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

• The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

• Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

• Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object or a ball, respectively).

• Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.

• A system of objects may also contain stored (potential) energy, depending on their relative positions. Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

• When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

• The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

• Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

Life science
• Plants, algae (including phytoplankton), and many microorganisms use energy from light to make sugars (food) from carbon dioxide from the atmosphere and water, through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

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• Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules to support growth or to release energy.

Earth and space sciences

• All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.

• The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

UNIT 3 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.

Physical science

• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

• These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position) of the particles. In some cases, the relative position of energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.

• Energy cannot be created nor destroyed, but it can be transported from one place to another and transferred between systems.

• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. The availability of energy limits what can occur in any system.

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• Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).

• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Life science

• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

• As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

• Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.

• Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

• Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

• As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

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UNIT 3 Links to Free and Low Cost Instructional Resources
Note- The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials. • American Association for the Advancement of Science: http://www.aaas.org/programs • American Chemical Society: http://www.acs.org/content/acs/en/education.html • Concord Consortium: Virtual Simulations: http://concord.org/ • International Technology and Engineering Educators Association: http://www.iteaconnect.org/ • National Earth Science Teachers Association: http://www.nestanet.org/php/index.php • National Science Digital Library: https://nsdl.oercommons.org/ • National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx • North American Association for Environmental Education: http://www.naaee.net/ • Phet: Interactive Simulations https://phet.colorado.edu/ • Science NetLinks: http://www.aaas.org/program/science-netlinks • Dynamic Equilibrium: Students will define what is meant by dynamic equilibrium. • Equlibrium and Le Chatlier's Principle: Students identify the factors that affect equilibrium and how the system responds to the change. Collision Theory and Rates of Reaction: Students use the virtual simulation to observe how a chemical reaction occurs. • Control a Haber-Bosch Ammonia Plant: You will learn about the economics of operating a chemical factory as you try to optimize the process of a simulated

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• Haber-Bosch process ammonia fertilizer plant.

UNIT 3 Appendix A: NGSS and Foundations for the Unit
Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. *[Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]* **(HS-PS1-4)**
Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. *[Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]* **(HS-PS1-5)**
Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* *[Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]* **(HS-PS1-6)**
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. *[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]* **(HS-LS1-5)**
Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. *[Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]* **(HS-LS1-7)**
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (HS-ETS1-2)

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The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8) • Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3) Using Mathematics and Computational Thinking • Use mathematical representations of phenomena to support claims. (HS-PS1-7) Constructing Explanations and Designing Solutions	PS1.A: Structure and Properties of Matter • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) PS1.B: Chemical Reactions • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5) • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7) ETS1.C: Optimizing the Design Solution	Patterns • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5) Energy and Matter • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) - *Connections to Nature of Science* Scientific Knowledge Assumes an Order and Consistency in Natural Systems • Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

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• Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) • Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6) Asking Questions and Defining Problems • Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) Using Mathematics and Computational Thinking • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (secondary to HS-PS1-6) ETS1.A: Defining and Delimiting Engineering Problems • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) ETS1.B: Developing Possible Solutions • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) • Both physical models and computers can be used in various ways to aid in the engineering	Energy and Matter • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6) • Energy cannot be created nor destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS1-7)

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Constructing Explanations and Designing Solutions • Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)	design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) ETS1.C: Optimizing the Design Solution • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2) LS1.C: Organization for Matter and Energy Flow in Organisms • The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5) • The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HS-LS1-6) • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in	

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	different ways to form different products. (HS-LS1-6),(HS-LS1-7) • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7)	

UNIT 3 Embedded English Language Arts/Literacy and Mathematics	
English Language Arts/Literacy	
RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS1-6)
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-5) (HS-LS1-6)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection and research (HS-LS1-6)
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1),(HS-ETS1-3)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-5)

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WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-6)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)
Mathematics -	
MP.2	Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7),(HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-PS1-4), (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4)
HSF-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-LS1-4)
HSF-BF.A.1	Write a function that describes a relationship between two quantities. (HS-LS1-4)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-4),(HS-PS1-5),(HS-PS1-7)

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Unit 4: Bonding and Chemical Reactions

Instructional Days: 30

This unit is based on HS-PS1-7, HS-PS1-4, HS-PS1-5, HS-PS1-6, and HS-ETS1-2.

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UNIT 4 : Bonding and Chemical Reactions	Instructional Days: 30
How do Earth's geochemical processes and human activities affect each other? In this unit of study, students use cause and effect to develop models and explanations for the ways that feedbacks among different Earth systems control the appearance of Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface (e.g., volcanism and mountain building), and the sun-driven surface systems that tear down the land through weathering and erosion. Students begin to examine the ways that human activities cause feedbacks that create changes to other systems. Students understand the system interactions that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students model the flow of energy and matter between different components of the weather system and how this affects chemical cycles such as the carbon cycle. Engineering and technology figure prominently here, as students use mathematical thinking and the analysis of geoscience data to examine and construct solutions to the many challenges facing long-term human sustainability on Earth. Here students will use these geoscience data to explain climate change over a wide range of timescales, including over one to ten years: large volcanic eruption, ocean circulation; ten to hundreds of years: changes in human activity, ocean circulation, solar output; tens of thousands to hundreds of thousands of years: changes to Earth's orbit and the orientation of its axis; and tens of millions to hundreds of millions of years: long-term changes in atmospheric composition). Note: This unit may be assessed by a performance based assessment (project, debate, presentation, etc.).	

UNIT 4 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.
Textbook Modern Chemistry, Raymond E. Davis Boston: HOLT, RINEHART AND WINSTON (2006). *Core Instructional Materials* • Laptop Cart • Microsoft office • CD-Rom Chemistry • Internet resources • Virtual Labs **Labs:** flame test lab, spectroscopy lab, spin-off of Rudolfium lab

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Links to Activities:

StellarSpectra: Students analyze bright line spectra of stars for evidence of a red shift.

Spectrum Simulator: Allows you to simulate various spectra for discussion.

Spectrum Simulation: Interactive periodic table where students can see the emission spectrum for each element.

AnalysisofSpectralLinesInklewriter: Interactive story based on a pogil for students to evaluate how a bright line spectrum is produced and how it can be used to identify elements.

NuclearFissionPhETSimulation: Online interactive simulator for nuclear fission, chain reactions and nuclear reactors.

EMSpectrum Module:

HydrogenAtomSimulator: Model the interactions of a hydrogen atom with light to discuss the quantum nature of absorption and emission.

3viewsspectrum demonstrator: View the difference in spectra between a hot incandescent light bulb and a cold, thin, gas cloud.

OnlineSimulationofaNuclearReactor

ExtrasolarPlanetRadialVelocityDemonstrator: View the shift in spectrum as a planet and star orbit their center of mass.

DopplerShiftSimulator

NuclearFissionSimulation: Shoot a neutron at a nucleus of uranium-235. The nucleus splits and you can discuss how the number of protons and neutrons were conserved as two different elements were formed from the original nucleus.
Links to Activities:
Ionic Bonding Interactive Game: Students fit together cations and anions to create ionic compounds.

Molecular Geometry : Students evaluate how the number of bonds and lone pairs of electrons determine the shape of a molecule.

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Types of Chemical Reactions : Students apply the analogy of dancing to identify different types of reactions. Balancing Chemical Reactions: Students demonstrate how to balance a chemical equation.

UNIT 4 Student Learning Objectives **INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS & BLUE CODE NUMBERS**
Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. *[Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]* **(HS-ESS2-4)**
Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. *[Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]* **(HS-ESS2-6)**
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. *[Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-1)**
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. *[Note: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-2)**
Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. *[Note: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-3)**
Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. *[Note: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-4)**

Part A: *What happens if we change the chemical composition of our atmosphere?* CONNECTION TO LESSON PLAN HERE	
Concepts **INSERT CHAPTER KEY CONCEPTS FROM SUMMARY HERE**	**Formative Assessment** **INSERT CHAPTER OBJECTIVE FROM BOOK SECTION**

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• The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	*Students who understand the concepts are able to:* • Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. • Use empirical evidence to differentiate between how variations in the flow of energy into and out of Earth's systems result in climate changes. • Use multiple lines of evidence to support how variations in the flow of energy into and out of Earth's systems result in climate changes.

Part B: *How does carbon cycle among the hydrosphere, atmosphere, geosphere, and biosphere?*	
Concepts	**Formative Assessment**

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• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. • The total amount of energy and matter in closed systems is conserved. • The total amount of carbon cycling among and between the hydrosphere, atmosphere, geosphere, and biosphere is conserved.	*Students who understand the concepts are able to:* • Develop a model based on evidence to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. • Develop a model based on evidence to illustrate the biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere, providing the foundation for living organisms.

UNIT 4 What It Looks Like in the Classroom
This unit of study continues looking at matter and energy, with a focus on weather and climate, carbon cycling, and the cause-and-effect relationships between human activity and Earth's systems. Students will examine causes of variations in the flow of energy into and out of Earth's systems and how climate is affected by these variations. They will also determine how the amount of carbon cycling in Earth's systems has changed over time, and how humans are influenced by resource availability, natural hazards, and climate change. Students should develop an understanding of how the foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. They should also examine how cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the Earth. These phenomena cause a cycle of ice ages and other gradual climate changes. Students might conduct research to locate and analyze data sets showing these phenomena. In order to determine how changes in the atmosphere due to human activity have increased the carbon dioxide concentrations and affected climate, students should look at cycles of differing timescales and their effects on climate. Geoscience data should be used to explain climate change over a wide-range of timescales, including one to ten years: large volcanic eruptions, ocean circulation; ten to hundreds of years: changes in human activity, ocean circulation, solar output; tens of thousands to hundreds of thousands of years: changes to Earth's orbit and the orientation of its axis; and tens of millions to hundreds of millions of years: long-term changes in

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atmospheric composition. Students might also explore Earth's climate history through an analysis of datasets such as the Keeling Curve or Vostok ice core data.

Students can use a jigsaw activity to examine data for an assigned timescale and event to show cause-and-effect relationships among energy flow into and out of Earth's systems and the resulting in changes in climate.

Students should use models to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. Models should be supported by multiple lines of evidence, and students should use digital media in presentations to enhance understanding. Students might use mathematical models, and they should identify important quantities and map relationships using charts and graphs. Mathematical models should include appropriate units and limitations on measurement should be considered.

Students will continue their study of Earth's systems by examining the history of the atmosphere. Students should research the early atmospheric components and the changes that occurred due to plants and other organisms removing carbon dioxide and releasing oxygen. By studying the carbon cycle, students should revisit the idea that matter and energy within a closed system are conserved among the hydrosphere, atmosphere, geosphere, and biosphere. Students should extend their understanding of how human activity affects the concentration of carbon dioxide in the environment and therefore climate. Students' experiences should include synthesizing information from multiple sources and developing quantitative models based on evidence to describe the cycling of carbon among the ocean, atmosphere, soil, and biosphere.

Students should understand how biogeochemical cycles provide the foundation for living organisms. Once again, students might use a jigsaw activity to illustrate the relationships between these systems. Finally, making a connection to engineering, students will investigate the cause-and-effect relationships between the interdependence of human activities and Earth's systems. Students should construct an explanation based on evidence for relationships between human activity and changes in climate. Students can revisit the idea of renewable and nonrenewable resources touched upon in unit 4, and further investigate their availability. Examples of key natural resources should include access to fresh water, fertile soil, and high concentrations of minerals and fossil fuels. Students should also examine natural hazards including interior processes (volcanic eruptions and earthquakes); surface processes (tsunamis, mass wasting, and soil erosion); and severe weather (hurricanes, floods, and droughts). Additionally, other geologic events that have driven the development of human history (including populations and migrations) should also be researched. These geologic events include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised. Students must use empirical evidence to identify differences between cause and correlation in the relationship between climate changes and human activity. Students should also use empirical evidence to make claims about causes and effects of these interactions. The influence of major technological systems on modern civilizations should be emphasized. Because all the scientific and engineering practices and crosscutting concepts are necessary for mastery of the scientific content in this unit, it is an opportunity for students to engage in problem solving using the

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complete engineering design cycle. Research and examination of data to determine relationships between global change and human activity will allow students to identify and analyze a major global challenge.

Students should take into account possible qualitative and quantitative criteria and constraints for solutions and examine the needs of society in response to the identified major global challenge. The students could then design a solution to this real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. They must then evaluate their solution based on prioritized criteria and tradeoffs (e.g., cost, safety, reliability, aesthetics, and possible social, cultural, and environmental impacts). Finally, students might use computer simulations along with mathematics and computational thinking to model the impact of their proposed solution. Their simulation must take into account the numerous criteria and constraints on interactions within and between systems relevant to the problem. For example, major global challenges might include ozone depletion, melting glaciers, rising sea levels, changes in climate and extreme weather, ocean acidification, aerosols and smog, melting permafrost, destruction of rainforests, and biome migration. Some local challenges students might consider include fishing industry quotas vs. economic impact on local fishing fleets (i.e., New Bedford, Galilee, Jerusalem); flood plain construction vs. housing restrictions on ocean beach fronts (i.e., Mantoloking, Seaside Heights); design of possible solutions to retard or prevent further beach erosion; and response to recent flooding in Rhode Island and flood plain restoration.

Integration of engineering -

The standards in this unit do not identify a connection to engineering; however, the nature of the content lends itself to real-world problem identification and solution design, testing, and modification. Students can use their understanding of energy and matter and system interactions from the previous units to guide their thinking about climate change, its effects on humans, the adverse effects of human activities, and potential solutions to contemporary issues regarding climate change. In this unit, students have the opportunity to complete the entire engineering cycle (ETS1-1, ETS1-2, ETS1-3, and ETS1-4) by analyzing a major global challenge related to climate change and human activity, designing and evaluating a possible solution to this problem, and further using a computer simulation to model the impact of the proposed solution.

UNIT 4 Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum.
English Language Arts/Literacy- • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations describing how variations in the flow of energy into and out of Earth's systems result in changes in climate to enhance understanding of findings, reasoning, and evidence and to add interest.

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• Cite specific textual evidence of the availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

• Use empirical evidence to write an explanation for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Mathematics-

• Represent symbolically an explanation for how variations in the flow of energy into and out of Earth's systems result in changes in climate, and manipulate the representing symbols. Use symbols to make sense of quantities and relationships about how variations in the flow of energy into and out of Earth's systems result in changes in climate, symbolically and manipulate representing symbols.

• Use a mathematical model to explain how variations in the flow of energy into and out of Earth's systems result in changes in climate. Identify important quantities in variations in the flow of energy into and out of Earth's systems result in changes in climate and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Use units as a way to understand problems and to guide the solution of multistep problems about how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret units consistently in formulas representing how variations in the flow of energy into and out of Earth's systems result in changes in climate; choose and interpret the scale and the origin in graphs and data displays representing how variations in the flow of energy into and out of Earth's systems result in changes in climate.

• Define appropriate quantities for the purpose of descriptive modeling of how variations in the flow of energy into and out of Earth's systems result in changes in climate.

• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities to describe how variations in the flow of energy into and out of
Earth's systems result in changes in climate.

• Represent symbolically the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere, and manipulate the representing symbols. Make sense of quantities and relationships in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

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• Use a mathematical model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. Identify important quantities in the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

• Use units as a way to understand the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere; choose and interpret units consistently in formulas representing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere; choose and interpret the scale and the origin in graphs and data displays representing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

• Define appropriate quantities for the purpose of descriptive modeling of the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities showing the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

• Represent symbolically how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity, and manipulate the representing symbols. Make sense of quantities and relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

• Use units as a way to understand the relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity. Choose and interpret units consistently in formulas to determine relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity. Choose and interpret the scale and the origin in graphs and data displays representing relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

• Define appropriate quantities for the purpose of descriptive modeling of relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

• Choose a level of accuracy appropriate to limitations on measurement when reporting quantities showing relationships among availability of natural resources, occurrence of natural hazards, and changes in climate and their influence on human activity.

UNIT 4 Modifications for special education students, English language learners, students at risk of school failure and gifted students

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Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.

• Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.

• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

• Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).

• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).

• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.

• Use project-based science learning to connect science with observable phenomena.

• Structure the learning around explaining or solving a social or community-based issue.

• Provide ELL students with multiple literacy strategies.

• Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 4 Research on Student Learning
Students of all ages may confuse the ozone layer with the greenhouse effect, and may have a tendency to imagine that all environmentally friendly actions help to solve all environmental problems (for example, that the use of unleaded petrol reduces the risk of global warming). Students have difficulty linking relevant elements of knowledge when explaining the greenhouse effect and may confuse the natural greenhouse effect with the enhancement of that effect.

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The idea of energy conservation seems counterintuitive to middle- and high-school students who hold on to the everyday use of the term energy, but teaching heat dissipation ideas at the same time as energy conservation ideas may help alleviate this difficulty. Even after instruction, however, students do not seem to appreciate that energy conservation is a useful way to explain phenomena. A key difficulty students have in understanding conservation appears to derive from not considering the appropriate system and environment. In addition, middle- and high-school students tend to use their conceptualizations of energy to interpret energy conservation ideas. For example, some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form. Or, students may believe that no energy remains at the end of a process, but may say that "energy is not lost" because an effect was caused during the process (for example, a weight was lifted). Although teaching approaches which accommodate students' difficulties about energy appear to be more successful than traditional science instruction, the main deficiencies outlined above remain despite these approaches (NSDL, 2015).

UNIT 4 Prior Learning
Physical science- • Substances are made from different types of atoms, which combine with one another in various ways. • Atoms form molecules that range in size from two to thousands of atoms. • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.

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• A system of objects may also contain stored (potential) energy, depending on the objects' relative positions.

• Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

• When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

• The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

• Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

• When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

• The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.

• A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.

• However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

• When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

• The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

• Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

Life science-

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• Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

• Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth or to release energy.

• Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

• Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.

• Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

• Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

• A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions.

• If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

• Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.

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• Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

Earth and Space Science-

• Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes.

• Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

• Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, and a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and the gravitational movement of denser materials toward the interior.

• The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

• The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.

• Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.

• The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

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• The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.

• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.

• Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

• Resource availability has guided the development of human society.

• All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits.
New technologies and social regulations can change the balance of these factors.

• Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

• Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

• Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.

• Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

UNIT 4 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers.
Physical science- • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those elements with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

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• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

• A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.

• In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.

• The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

• These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases, the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.

• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

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• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

• The availability of energy limits what can occur in any system.

• Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).

• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Life science-

• The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

• The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.

• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

• As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

• Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.

• Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions,

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some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

• Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

• A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions.
If a modest biological or physical disturbance to an ecosystem occurs, the ecosystem may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

• Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.

Earth and Space Sciences-
• Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.

• Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.

• The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

• Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

• Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.

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• Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

UNIT 4 Links to Free and Low Cost Instructional Resources
Note- The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials. • American Association for the Advancement of Science: http://www.aaas.org/programs • American Chemical Society: http://www.acs.org/content/acs/en/education.html • Concord Consortium: Virtual Simulations: http://concord.org/ • International Technology and Engineering Educators Association: http://www.iteaconnect.org/ • National Earth Science Teachers Association: http://www.nestanet.org/php/index.php • National Science Digital Library: https://nsdl.oercommons.org/ • National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx • North American Association for Environmental Education: http://www.naaee.net/ • Phet: Interactive Simulations https://phet.colorado.edu/ • Science NetLinks: http://www.aaas.org/program/science-netlinks • Carbon Cycle Lab from Annenberg Learner : Simulation to model the carbon cycle and human impact on the cycle • Interactive Energy Lab from Annenberg Learner: Students manipulate the energy sources of the world to view how shifting from fossil fuels to renewables could affect the global energy budget.

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• Magma Interactive: Students manipulate the temperature, pressure, and content settings of magma. • Interpreting Ozone Layer Data: Data analysis activity using ozone layer data

UNIT 4 Appendix A: NGSS and Foundations for the Unit
Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. *[Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]* **(HS-ESS2-4)**
Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. *[Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]* **(HS-ESS2-6)**
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. *[Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-1)**
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. *[Note: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-2)**
Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. *[Note: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-3)**
Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. *[Note: See Three-Dimensional Teaching and Learning Section for examples.]* **(HS-ETS1-4)**

The Student Learning Objectives above were developed using the following elements from the NRC document A Framework for K-12 Science Education:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models ● Develop a model based on evidence to illustrate the relationships between	ESS1.B: Earth and the Solar System ● Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the	Cause and Effect ● Empirical evidence is required to differentiate between cause and

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systems or between components of a system. (HS-ESS2-1),(HS-ESS2-3),(HS-ESS2-6) ● Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4) Asking Questions and Defining Problems ● Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) Using Mathematics and Computational Thinking ● Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4) Constructing Explanations and Designing Solutions ● Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)	tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary to HS-ESS2-4)* ESS2.A: Earth Materials and Systems ● The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4) ESS2.D: Weather and Climate ● The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4) ● Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) ● Changes in the atmosphere due to human	correlation and make claims about specific causes and effects. (HS-ESS2-4) Energy and Matter ● The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6) Systems and System Models ● Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-ETS1-4) - *Connections to Engineering, Technology, and Applications of Science* Influence of Science, Engineering, and Technology on Society and the Natural World ● New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3) *Connections to Nature of Science* Scientific Knowledge is Based on Empirical Evidence

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	activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6),(HS-ESS2-4) ETS1.A: Defining and Delimiting Engineering Problems ● Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) ● Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) ETS1.B: Developing Possible Solutions ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) ● Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a	● Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4)

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	problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) ETS1.C: Optimizing the Design Solution ● Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)	

UNIT 4 Embedded English Language Arts/Literacy and Mathematics Standards	
English Language Arts/Literacy	
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1),(HS-ETS1-3)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-1),(HS-ETS1-3)
Mathematics	
MP.2	Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7),(HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-PS1-4), (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),(HS-PS1-7)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-4),(HS-PS1-5),(HS-PS1-7)

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Unit 5: Nuclear Chemistry
Instructional Days: 30

This unit is based on HS-PS1-8, HS-ESS1-3, HS-ESS1-1, HS-ESS1-2, and HS-ESS1-6

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UNIT 5: Nuclear Chemistry	Instructional Days: 30

What happens in stars?

In this unit of study, energy and matter are studied further by investigating the processes of nuclear fusion and fission that govern the formation, evolution, and workings of the solar system in the universe. Some concepts studied are fundamental to science and demonstrate scale, proportion, and quantity, such as understanding how the matter of the world formed during the Big Bang and within the cores of stars over the cycle of their lives.

In addition, an important aspect of Earth and space sciences involves understanding the concept of stability and change while making inferences about events in Earth's history based on a data record that is increasingly incomplete the farther one goes back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record.

The crosscutting concepts of energy and matter; scale, proportion, and quantity; and stability and change are called out as organizing concepts for this unit. Students are expected to demonstrate proficiency in developing and using models; constructing explanations and designing solutions; using mathematical and computational thinking; and obtaining, evaluating, and communicating information; and they are expected to use these practices to demonstrate understanding of the core ideas.

UNIT 5 List of core instructional materials, including various levels of texts at each grade level benchmark assessments.

Textbook

Modern Chemistry, Raymond E. Davis Boston: HOLT, RINEHART AND WINSTON (2006).

Core Instructional Materials

- Laptop Cart
- Microsoft office
- CD-Rom Chemistry
- Internet resources
- Virtual Labs

Labs: flame test lab, spectroscopy lab, spin-off of Rudolfium lab

Links to Activities:

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StellarSpectra: Students analyze bright line spectra of stars for evidence of a red shift.

Spectrum Simulator: Allows you to simulate various spectra for discussion.

Spectrum Simulation: Interactive periodic table where students can see the emission spectrum for each element.

AnalysisofSpectralLinesInklewriter: Interactive story based on a pogil for students to evaluate how a bright line spectrum is produced and how it can be used to identify elements.

NuclearFissionPhETSimulation: Online interactive simulator for nuclear fission, chain reactions and nuclear reactors.

EMSpectrum Module:

HydrogenAtomSimulator: Model the interactions of a hydrogen atom with light to discuss the quantum nature of absorption and emission.

3viewsspectrum demonstrator: View the difference in spectra between a hot incandescent light bulb and a cold, thin, gas cloud.

OnlineSimulationofaNuclearReactor

ExtrasolarPlanetRadialVelocityDemonstrator: View the shift in spectrum as a planet and star orbit their center of mass.

DopplerShiftSimulator

NuclearFissionSimulation: Shoot a neutron at a nucleus of uranium-235. The nucleus splits and you can discuss how the number of protons and neutrons were conserved as two different elements were formed from the original nucleus.

Links to Activities:

Ionic Bonding Interactive Game: Students fit together cations and anions to create ionic compounds.

Molecular Geometry : Students evaluate how the number of bonds and lone pairs of electrons determine the shape of a molecule.

Types of Chemical Reactions : Students apply the analogy of dancing to identify different types of reactions.

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Balancing Chemical Reactions: Students demonstrate how to balance a chemical equation.

UNIT 5 Student Learning Objectives INSERT NEXTGEN STANDARDS HERE WITH RED CLARIFICATION STATEMENTS & BLUE CODE NUMBERS
Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. *[Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]* **(HS-PS1-8)**
Communicate scientific ideas about the way stars, over their life cycle, produce elements. *[Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]* **(HS-ESS1-3)**
Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. *[Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.]* **(HS-ESS1-1)**
Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. *[Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]* **(HS-ESS1-2)**
Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. *[Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]* **(HS-ESS1-6)**

UNIT 5 Quick Links

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Part A: *Why is fusion considered the Holy Grail for the production of electricity? Why aren't all forms of radiation harmful to living things?* CONNECTION TO LESSON PLAN HERE	
Concepts **NSERT CHAPTER KEY CONCEPTS FROM SUMMARY HERE**	**Formative Assessment** **INSERT CHAPTER OBJECTIVE FROM BOOK SECTION**
• Nuclear processes, including fusion, fission, and radioactive decay of unstable nuclei, involve release or absorption of energy. • The total number of neutrons plus protons does not change in any nuclear process. • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	*Students who understand the concepts are able to:* • Develop models based on evidence to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. • Use simple qualitative models based on evidence to illustrate the scale of energy released in nuclear processes relative to other kinds of transformations. • Develop models based on evidence to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of alpha, beta, and gamma radioactive decays.

Part B: *How do stars produce elements?*	
Concepts	**Formative Assessment**
• The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. Other than the hydrogen and helium formed	*Students who understand the concepts are able to:*

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at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	• Communicate scientific ideas in multiple formats (including orally, graphically, textually, and mathematically) about the way stars, over their life cycles, produce elements. • Communicate scientific ideas about the way nucleosynthesis, and therefore the different elements it creates, vary as a function of the mass of a star and the stage of its lifetime. • Communicate scientific ideas about how in nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Part C: *Is the life span of a star predictable?*	
Concepts	**Formative Assessment**
• The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. • Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. • The significance of the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth is dependent on the scale, proportion, and quantity at which it occurs.	*Students who understand the concepts are able to:* • Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core in releasing energy that eventually reaches Earth in the form of radiation. • Develop a model based on evidence to illustrate the relationships between nuclear fusion in the sun's core and radiation that reaches Earth.

Part D: *If there was nobody there to Tweet about it, how do we know that there was a Big Bang?*	
Concepts	**Formative Assessment**
• The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	*Students who understand the concepts are able to:* • Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

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• The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and will continue to do so in the future. • Science assumes the universe is a vast single system in which basic laws are consistent. • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	• Construct an explanation of the Big Bang theory based on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars). • Construct an explanation based on valid and reliable evidence that energy in the universe cannot be created or destroyed, only moved between one place and another place, between objects and/or fields, or between systems.

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• Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element even in microscopic quantities. • Energy cannot be created or destroyed, only moved between one place and another place, between objects and/or fields, or between systems.	

Part E: *How can chemistry help us to figure out ancient events?*	
Concepts	**Formative Assessment**
• Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. • Much of science deals with constructing explanations of how things change and how they remain stable.	*Students who understand the concepts are able to:* • Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. • Use available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. • Apply scientific reasoning to link evidence from ancient Earth materials, meteorites, and other planetary surfaces to claims about Earth's formation and early history, and assess the extent to which the reasoning and data support the explanation or conclusion. • Use available evidence within the solar system to construct explanations for how Earth has changed and how it remains stable.

UNIT 5 What It Looks Like in the Classroom
This unit of study continues looking at energy flow and matter but with a new emphasis on Earth and space science in relation to the history of Earth starting with the Big Bang theory. Students will also explore the production of elements in stars and radioactive decay. Students should develop and use models to illustrate the processes of fission, fusion, and radioactive decay and the scale of energy

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released in nuclear processes relative to other kinds of transformations, such as chemical reactions. Models should be qualitative, based on evidence, and might include depictions of radioactive decay series such as Uranium-238, chain reactions such as the fission of Uranium-235 in reactors, and fusion within the core of stars. Students could also explore the PhET nuclear fission inquiry lab and graphs to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of alpha, beta, and gamma radioactive decays. When modeling nuclear processes, students should depict that atoms are not conserved, but the total number of protons plus neutrons is conserved. Models should include changes in the composition of the nucleus of atoms and the scale of energy released in nuclear processes.

The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. Other than hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. Because atoms of each element emit and absorb characteristic frequencies of light, the presence of an element can be detected in stars and interstellar gases. Students should develop an understanding of how analysis of light spectra gives us information about the composition of stars and interstellar gases. Communication of scientific ideas about how stars produce elements should be done in multiple formats, including orally, graphically, textually, and mathematically. The conservation of the total number of protons plus neutrons is important in their explanations, and students should cite supporting evidence from text.

Students should also use the sun as a model for the lifecycle of a star. This model should also illustrate the relationship between nuclear fusion in the sun's core and energy that reaches the Earth in the form of radiation. Students could construct a mathematical model of nuclear fusion in the sun's core, identifying important quantities and factors that affect the life span of the sun. They should also be able to use units and consider limitations on measurement when describing energy from nuclear fusion in the sun's core that reaches the Earth. For example, students should be able to quantify the amounts of energy in joules when comparing energy sources. In this way, students will develop an understanding of how our sun changes and how it will burn out over a lifespan of approximately 10 billion years.

This unit continues with a study of how astronomical evidence ("red shift/blue shift," wavelength relationships to energy, and universe expansion) can be used to support the Big Bang theory. Students should construct an explanation of the Big Bang theory based on evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. Students should explore and cite evidence from text of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of primordial radiation that still fills the universe. The concept of conservation of energy should be evident in student explanations. Students should also be aware that a scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. Students should also know that if new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of the new evidence.

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Students should be able to cite specific evidence from text to support their explanations of the life cycle of stars, the role of nuclear fusion in the sun's core, and the Big Bang theory. In their explanations, they should discuss the idea that science assumes the universe is a vast single system in which laws are consistent.

This unit concludes with the application of scientific reasoning and the use of evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of the Earth's formation and early history. For example, students will use examples of spontaneous radioactive decay as a tool to determine the ages of rocks or other materials (K-39 to Ar-40). Students should make claims about Earth's formation and early history supported by data while considering appropriate units, quantities and limitations on measurement. Students might construct graphs showing data on the absolute ages and composition of Earth's rocks, lunar rocks, and meteorites. Using available evidence within the solar system, students should construct explanations for how the earth has changed and how it has remained stable in its 4.6 billion year history.

UNIT 5 Connecting with English Language Arts/Literacy and Mathematics. Interdisciplinary connections through the K-12 curriculum	
English Language Arts/Literacy	
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS1-1)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-3), (HS-ESS1-2)
SL.11-12.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-ESS1-3)
Mathematics	
MP.2	Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-2) ,(HS-ESS1-3) ,(HS-PS1-8)
MP.4	Model with mathematics. (HS-ESS1-1)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1),(HS-ESS1-2)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-2)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1), (HS-ESS1-2)
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1)

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HSA-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-ESS1-1), (HS-ESS1-2)
HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1),(HS-ESS1-2)

UNIT 5 Modifications for special education students, English language learners, students at risk of school failure and gifted students

Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.

• Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

• Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.

• Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

• Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).

• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).

• Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.

• Use project-based science learning to connect science with observable phenomena.

• Structure the learning around explaining or solving a social or community-based issue.

• Provide ELL students with multiple literacy strategies.

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• Collaborate with after-school programs or clubs to extend learning opportunities.

UNIT 5 Research on Student Learning
1. Who asks the question? That is, who asks the question that focuses the investigation (e.g., “What effect does the tilt of the earth have on seasons?” or “What effect does pH have on litmus paper?” or “Which antacid best neutralizes acid?”)? Is it the student or the teacher/book? In most curricula, these are an element given in the materials. As an educator you need to look for labs that, at least on a periodic basis, allow students to pursue their own questions. 2. Who designs the procedures? We are speaking here of lab procedures or the steps in an investigation. Who designs this process for gathering information? In order to gain experience with the logic underlying experimentation, students need continuous practice with designing procedures. Some labs, where the primary target is content acquisition, designate procedures. But others should ask students to do so. 3. Who decides what data to collect? This is similar to designing procedures, but the focus is on the data itself. What data is important and who determines that? Students need practice in determining the data to collect. 4. Who formulates explanations based upon the data? Do the text materials give the answers? Or do questions at the end of activities make students analyze and draw conclusions based on their data? The bottom line—Do the questions make students think? 5. Who communicates and justifies the results? Do activities push students to not only communicate but also justify their answers? Are activities thoughtfully designed and interesting so that students want to share their results and argue about conclusions?

UNIT 5 Prior Learning
Physical Science • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.

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• In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.

• Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

• The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

• Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

• The total number of each type of atom is conserved, and thus the mass does not change.

• Some chemical reactions release energy, others store energy.

• When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

• The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.

• A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.

• However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Earth and Space Science
• Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.

• Earth and its solar system are part of the Milky Way Galaxy, which is one of many galaxies in the universe.

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• All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.

• The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

• Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.

• Because these patterns are so complex, weather can only be predicted via probability & statistics.

• The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

UNIT 5 Integration of 21st century themes and skills. Connections to Other Courses. Technology and 21st Century Life and Careers
Physical science • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places elements with similar chemical properties in columns. • The repeating patterns of this table reflect patterns of outer electron states. • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.

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• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

• Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.

• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

• The availability of energy limits what can occur in any system.

• Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).

• When two objects interacting through a field change relative position, the energy stored in the field is changed.

• Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

• Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.

• When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

• Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

Earth and Space Science

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• The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. • Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.

UNIT 5 Sample of Open Education Resources

UNIT 5 Links to Free and Low Cost Instructional Resources
Note- The majority of the student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials. • American Association for the Advancement of Science: http://www.aaas.org/programs • American Chemical Society: http://www.acs.org/content/acs/en/education.html

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- Concord Consortium: Virtual Simulations: http://concord.org/

- International Technology and Engineering Educators Association: http://www.iteaconnect.org/

- National Earth Science Teachers Association: http://www.nestanet.org/php/index.php

- National Science Digital Library: https://nsdl.oercommons.org/

- National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx

- North American Association for Environmental Education: http://www.naaee.net/

- Phet: Interactive Simulations https://phet.colorado.edu/

- Science NetLinks: http://www.aaas.org/program/science-netlinks

- Stellar Spectra: Students analyze bright line spectra of stars for evidence of a red shift.

- Spectrum Simulator: Allows you to simulate various spectra for discussion.

- Spectrum Simulation: Interactive periodic table where students can see the emission spectrum for each element.

- Analysis of Spectral Lines Inklewriter: Interactive story based on a pogil for students to evaluate how a bright line spectrum is produced and how it can be used to identify elements.

- Nuclear Fission PhET Simulation: Online interactive simulator for nuclear fission, chain reactions and nuclear reactors.

- EM Spectrum Module:

- Hydrogen Atom Simulator: Model the interactions of a hydrogen atom with light to discuss the quantum nature of absorption and emission.

- 3 views spectrum demonstrator: View the difference in spectra between a hot incandescent light bulb and a cold, thin, gas cloud.

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• Online Simulation of a Nuclear Reactor • Extrasolar Planet Radial Velocity Demonstrator: View the shift in spectrum as a planet and star orbit their center of mass. • Doppler Shift Simulator • Nuclear Fission Simulation: Shoot a neutron at a nucleas of uranium-235. The nucleas splits and you can discuss how the number of protons and neutrons were conserved as two different elements were formed from the original nucleus. • Nuclear Fusion Simulation • Nuclear Chain Reaction simulation: Simulates both a controlled and an uncontrolled chain reaction within a nuclear reactor.

UNIT 5 Appendix A: NGSS and Foundations for the Unit
Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. *[Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]* **(HS-PS1-8)**
Communicate scientific ideas about the way stars, over their life cycle, produce elements. *[Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]* **(HS-ESS1-3)**
Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. *[Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.]* **(HS-ESS1-1)**
Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. *[Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big*

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Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).] **(HS-ESS1-2)**
Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. *[Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]* **(HS-ESS1-6)**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8),(HS-ESS1-1) Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of	PS1.C: Nuclear Processes • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8) • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.(secondary (HS-ESS1-6) ESS1.A: The Universe and Its Stars • The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1) • The study of stars' light spectra and brightness is used to identify compositional	Energy and Matter • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3), (HS-PS1-8), (HS-ESS1-1) • Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2) Scale, Proportion, and Quantity • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1) • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4)

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evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2) • Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) Using Mathematical and Computational Thinking Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical or computational	elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3) • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2) • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2),(HS-ESS1-3) PS3.D: Energy in Chemical Processes and Everyday Life • Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary) (HS-ESS1-1) PS4.B: Electromagnetic Radiation • Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. *(secondary)* HS-ESS1-2)	• In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) - *Connections to Engineering, Technology, and Applications of Science* Interdependence of Science, Engineering, and Technology • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2),(HS-ESS1-4) -- *Connections to Nature of Science* Scientific Knowledge Assumes an Order and Consistency in Natural Systems ● Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)

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representations of phenomena to describe explanations. (HS-ESS1-4) Obtaining, Evaluating, and Communicating Information • Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. (HS-ESS1-6) • Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3)	ESS1.B: Earth and the Solar System • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4) ESS1.C: The History of Planet Earth • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.	● Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2) Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2)

UNIT 5 Embedded English Language Arts/Literacy and Mathematics

English Language Arts/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS1-1)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-3),(HS-ESS1-2)
SL.11-12.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-ESS1-3)

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-2) ,(HS-ESS1-3) ,(HS-PS1-8)
MP.4	Model with mathematics. (HS-ESS1-1)

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HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1),(HS-ESS1-2)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-2)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1), (HS-ESS1-2)
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1)
HSA-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-ESS1-1), (HS-ESS1-2)
HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1),(HS-ESS1-2)

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SCIENCE PROGRAM RUBRIC

Criterion A. All Standards, All Students

Guiding Question: To what extent does the science program ensures that ALL students are provided appropriate learning opportunities for ALL of the standards. This includes, but is not limited to, students with disabilities, economically disadvantages, English Language Learners, and students who have been identified as gifted?

NJSLS-S designed programs do *not* look like this:	NJSLS-S designed Science Programs look *more* like this:
The curriculum is based on the table of contents from science instructional materials.	Districts designed new science curricula by analyzing the new science standards and then intentionally selecting the instructional tasks and resources needed to move students toward proficiency.
Students learn science when time allows.	The district has a balanced curriculum in which all disciplines (e.g. Science, Social Studies, Visual and Performing Arts, and World Languages) are afforded adequate time and resources.
High School students take only biology, chemistry, and physics and not provided instruction in Earth and space science.	Regardless of course title, students have an opportunity to demonstrate proficiency with all of the Physical Science, Life Science and Earth and Space Science standards.
The curriculum is *aligned* to the standards.	• Science units in grades K-8 identify the previous learning and future learning for each unit. • High school science courses identify previous learning using the NJSLS-S and future learning referencing AP or IB course information for each course. • Accommodations for Access and Equity are part of the planning, not an add-on.

Criterion B. Explaining Phenomena or Designing Solutions

Guiding Question: To what extent do the units focus on supporting students to make sense of engaging and authentic phenomena or design solutions to real-world problem?

NJSLS-S designed units look *less* like this:	NJSLS-S designed units look *more* like this:
Explaining phenomena and designing solutions are not a part of student learning or are presented separately from "learning time" (i.e. used only as a "hook" or engagement tool; used only for enrichment or reward after learning; only loosely connected to a DCI).	The purpose and focus of the units are to support students in making sense of phenomena and/or designing solutions to problems. The entire lesson drives toward this goal.

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The focus is only on getting the "right" answer to explain the phenomenon	Student sense-making of phenomena or designing of solutions is used as a window into student understanding of all three dimensions of the NJSLS-S.
A different, new, or unrelated phenomenon is used to start every lesson/unit.	Lessons/units work together in a coherent storyline to help students make sense of phenomena.
Teachers tell students about an interesting phenomenon or problem in the world.	Students get <u>direct</u> (preferably firsthand, or through media representations) experience with a phenomenon or problem that is relevant to them and is developmentally appropriate.
Phenomena are brought into the lessons/units after students develop the science ideas so students can apply what they learned.	The <u>development</u> of science ideas is anchored in explaining phenomena or designing solutions to problems.

<u>Criterion C. Three Dimensional</u>
<u>Guiding Question</u>: To what extent do the units help students develop and use multiple grade-appropriate elements of the science and engineering practices (SEP), disciplinary core ideas (DCI), and crosscutting concepts (CCC), which are deliberately selected to aid student sense-making of phenomena or designing of solutions?

NJSLS-S designed units look *less* like this:	NJSLS-S designed units look *more* like this:
A single practice element shows up throughout lessons.	Units help students use multiple (e.g., 2–4) practice elements as appropriate in their learning.
The units focuses on colloquial definitions of the practice or crosscutting concept names (e.g., "asking questions", "cause and effect") rather than on grade-appropriate learning goals (e.g., elements in NJSLS-S Appendices F &G).	Specific grade-appropriate elements of SEPs and CCCs (from NJSLS-S Appendices F & G) are <u>acquired</u>, <u>improved</u>, or <u>used</u> by students to help explain phenomena or solve problems during the lesson.
The SEPs and CCCs can be inferred by the teacher (not necessarily the students) from the lesson materials.	Students explicitly use the SEP and CCC elements to make sense of the phenomenon or to solve a problem.
Engineering lessons focus on trial and error activities that don't require science or engineering knowledge.	Engineering tasks require students to acquire and use elements of DCIs from physical, life, or Earth and space sciences together with elements of DCIs from engineering design (ETS) to solve design problems.

<u>Criterion D. Integrating the Three Dimensions for Instruction and Assessment</u>
<u>Guiding Question</u>: To what extent do the units require student performances that integrate elements of the SEPs, CCCs, and DCIs to make sense of phenomena or design solutions to problems, and the learning tasks elicit student artifacts that show direct, observable evidence of three-dimensional learning?

NJSLS-S designed units look *less* like this:	NJSLS-S designed units look *more* like this:

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Students learn the three dimensions in isolation from each other (e.g., a separate lesson or activity on science methods followed by a later lesson on science knowledge).	• The units are designed to build student proficiency in at least one grade- appropriate element from each of the three dimensions. • The three dimensions intentionally work together to help students explain a phenomenon or design solutions to a problem. • All three dimensions are necessary for sense-making and problem-solving.
Teachers assume that correct answers indicate student proficiency without the student providing evidence or reasoning.	Teachers deliberately seek out student artifacts that show direct, observable evidence of learning, building toward all three dimensions of the NJSLS-S at a grade- appropriate level.
Teachers measure only one dimension at a time (e.g., separate items for measuring SEPs, DCIs, and CCCs).	Teachers use tasks that ask students to explain phenomena or design solutions to problems, and that reveal the level of student proficiency in all three dimensions.
English language arts and/or mathematics are added onto units.	Students are using grade appropriate English language arts and mathematics to make sense of phenomena or when designing a solution.

Criterion E. Relevance and Authenticity

Guiding Question: To what extent do the units motivate student sense-making or problem- solving by taking advantage of student questions and prior experiences in the context of the students' home, neighborhood, and community?

NJSLS-S designed units look *less* like this:	NJSLS-S designed lessons/units look *more* like this:
The units teach a topic adults think is important.	The units motivate student sense-making or problem-solving
The units focus on examples that some of students in the class understand.	The units provide support to teachers for making connections to the lives of every student in the class.
Driving questions are given to students.	Student questions, prior experiences, and diverse backgrounds related to the phenomenon or problem are used to drive the units and the sense-making or problem-solving.
The units tell the students what they will be learning.	The units provide support to teachers or students for connecting students' own questions to the targeted materials.

Criterion F. Student Ideas

Guiding Question: To what extent does the lesson provide opportunities for students to express, clarify, justify, interpret, and represent their ideas (i.e., making thinking visible) and to respond to peer and teacher feedback?

NJSLS-S designed units look *less* like this:	NJSLS-S designed units look *more* like this:
The teacher is the central figure in classroom discussions.	• Classroom discourse focuses on explicitly expressing and clarifying student reasoning • Students have opportunities to share ideas and feedback with each other directly.
Student artifacts only show answers.	Student artifacts include elaborations (which may be written, oral, pictorial, and digital) of reasoning behind their answers, and show how students' thinking has changed over time.
The teacher's guide focuses on what to tell the students.	The unit provides items, tasks, and/or prompts to teachers for eliciting student ideas.

Criterion G. Building on Students' Prior Knowledge

Guiding Question: To what extent does the units identify and build on students' prior learning in all three dimensions in a way that is explicit to both the teacher and students?

NJSLS-S designed units look *less* like this:	NJSLS-S designed units look *more* like this:
The unit content builds on students' prior learning, but only for DCIs.	The unit content builds on students' prior learning in all three dimensions.
The unit does not include support to teachers for identifying students' prior learning.	The lesson provides explicit support to teachers for identifying students' prior learning and accommodating different entry points, and describes how the lesson will build on the prior learning.
The unit assumes that students are starting from scratch in their understanding.	The unit explicitly works together with students' foundational knowledge and practice from prior grade levels.

PRIMARY EVALUATION OF ESSENTIAL CRITERIA (PEEC)

NEXT GENERATION SCIENCE STANDARDS:

FOR ALIGNMENT

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INTRODUCTION

In April 2013, release of the Next Generation Science Standards (NGSS) set new priorities for science education in the United States. The NGSS and the National Research Council's (NRC) *A Framework for K-12 Science Education*, on which the NGSS were based, describe a vision of science education that is based on scientific advances and educational research. This research and resulting vision for science education have implications for instructional materials that reach far beyond minor adjustments to lessons, a few new activities, and supplements to curriculum units. The innovations implied by the NGSS must be accommodated by changes to entire science instructional programs.

A prior document, the Educators Evaluating the Quality of Instructional Products (EQuIP) NGSS Rubric, provided criteria by which to measure the alignment and quality of *individual lessons and units* with respect to the NGSS. In contrast, the following discussion was designed to accompany the EQuIP rubric and to additionally present criteria and processes that can be used to evaluate the NGSS alignment of *entire school science programs* — that is, school curriculum, textbooks, and support materials for teachers that are designed for both year-long and K–12 education. The goal of this document is to describe some critical components of school science programs that are aligned with the NGSS.

Shifting school programs to support the implementation of the NGSS will require many changes. The best response to this challenge would be to design brand new school science programs. This approach has the potential of developing a full school science program that most closely meets the vision described in *A Framework for K-12 Science Education*, the innovations set forth in the NGSS, and the recommendations from the foundational research. Although ideal, this approach has short term constraints of budget, time, and capacity to develop quality programs.

An alternative response to the short term needs is to adapt current instructional materials to incorporate the innovations described in the NGSS. This approach may address constraints of budget and time, but it may be significantly limited by the design of current programs and the degree to which the materials constituting those programs can be adapted to meet the NGSS.

Regardless of the approach, the first step is to thoroughly examine the differences between current science programs and those that are NGSS aligned. That is the primary emphasis of the following discussion.

REVIEWING INSTRUCTIONAL MATERIALS WITH PRIMARY EVALUATION OF ESSENTIAL CRITERIA FOR ALIGNMENT (PEEC-ALIGNMENT)

First, a few words about PEEC-Alignment. The acronym is intentionally a play on words. In one sense, the evaluation is a peek, or a quick look at a program. In another sense, this document describes a peak, the highest point, principal, or most important features of NGSS-aligned programs. PEEC-Alignment is designed to achieve both of these important goals.

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Before conducting a complete and likely time-consuming review, it is most efficient to get a sense of the issues and make a decision about the need for a thorough and complete review.

This document is meant to help reviewers answer the question: “Does the program under review contain or exhibit the essential features of an NGSS-based program?” For this goal, PEEC-Alignment centers on the innovations set forth in the NGSS and their implications for instructional materials. If the program under review does not incorporate the most primary innovations set forth in the NGSS, then there is little need to conduct a full, detailed review to determine if materials are fully aligned to the NGSS. In other words, PEEC-Alignment is only meant to be an evaluation of NGSS alignment. There are many additional criteria for quality instructional materials that are not listed in this document. The omission is not because they are not critical criteria, but merely because they are not unique to NGSS-aligned materials. Existing lists of essential criteria for quality instructional materials can and should be added to those in this document to help complete a more comprehensive review process if materials pass a screen with the PEEC-Alignment.

PEEC-Alignment can be used to evaluate a comprehensive science program (e.g., a school program based on different units), kit-based instructional materials (e.g., a kit program for elementary science), textbooks (e.g., a middle school Earth science textbook), or textbook series (e.g., a K–6 elementary program) to determine the degree to which they align with the NGSS. The target materials can include full programs (e.g., spanning several grade levels), year-long courses (e.g., high school biology), and support materials in print or digital formats. However, evaluation of programs that are built from several different sources (e.g., a combination of textbooks, kits, and digital supplements) will often be more challenging if there is not clear guidance for how the different components will be used together in classrooms.

PEEC-Alignment is designed for publishers, curriculum developers, educators, and administrators responsible for developing, revising, selecting, or purchasing comprehensive programs, textbooks, or textbook series based on the NGSS.

PEEC-Alignment can be used by publishers as:

Standards-alignment specifications for designing a new comprehensive NGSS-based program; or

Indications of changes required for the revision of a current program.

PEEC-Alignment can be used by educators for:

Aiding decisions about the review, selection, and purchasing of school science textbooks, textbook series, and instructional materials that represent comprehensive programs; or

Evaluation of current materials to identify adaptations and modifications to increase alignment with the NGSS.

Beginning on page 22, the accompanying Appendix describes and guides the PEEC-Alignment review process. The primary innovations from the *Framework* and the NGSS along with their implications for instructional materials and school programs are described below. However, this document does not substitute for the breadth and depth of information contained in the NGSS and the *Framework*, and a thorough knowledge of these documents is necessary before attempting to apply the PEEC-Alignment process to instructional materials.

NGSS INNOVATIONS

The architecture of the NGSS differs significantly from prior standards for science education. In the NGSS, the three dimensions of Science and Engineering Practices (SEPs), Disciplinary Core Ideas (DCIs), and Crosscutting Concepts (CCCs) are crafted into performance expectations that describe what is to be assessable following instruction. The NGSS performance expectations are therefore a measure of competency. The foundation boxes for each of the three dimensions provide additional information and clarity for the design or redesign of school programs.

Figure 1. Example of NGSS Architecture for Standards

2-PS1-1 Matter and Its Interactions

Students who demonstrate understanding can:

2-PS1-1. **Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.** [Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Planning and Carrying Out Investigations	**PS1.A: Structure and Properties of Matter**	**Patterns**
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	• Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties.	• Patterns in the natural and human designed world can be observed.

Connections to other DCIs in second grade: N/A

Articulation of DCIs across grade-levels:
5.PS1.A

Common Core State Standards Connections:
ELA/Literacy —

W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-PS1-1)

W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (2-PS1-1)

Mathematics —

MP.4 Model with mathematics. *(2-PS1-1)*

2.MD.D.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. *(2-PS1-1)*

A comprehensive program should provide opportunities for students to develop their understanding of DCIs through their engagement in SEPs and their application of CCCs. This three-dimensional learning leads to eventual mastery of performance expectations. In this perspective, a quality program should clearly describe or show how the cumulative learning experience works coherently with previous and following experiences to build scientific literacy.

The following innovations in the NGSS are hallmarks of current thinking about how students learn science, and they set a vision for future science education. These innovations will not only cause a shift in instructional programs in American classrooms but should also affect and refocus the efforts of curriculum developers and the design of comprehensive school science programs.

Innovation 1: K–12 science education reflects three-dimensional learning.

In the NGSS, science is described as having three distinct dimensions, each of which represents equally important learning outcomes: (1) SEPs, (2) DCIs, and (3) CCCs (The Next Generation Science Standards 2013). The NGSS expectations for students include making connections among all three dimensions. Students develop and apply the skills and abilities described in the SEP, as well as learn to make connections between different DCIs through the CCC to help gain a better understanding of the natural and designed world. Current research suggests that both knowledge (DCIs and CCCs) and practice (SEPs) are necessary for a full understanding of science.

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Each NGSS standard integrates one specific SEP, CCC, and DCI into a performance expectation that details what students should be proficient in by the end of instruction. In past standards the separation of skills and knowledge often led to an emphasis (in both instruction and assessment) on science concepts and an omission of inquiry and practices. It is important to note that the NGSS performance expectations do not specify or limit the intersection of the three dimensions in classroom instruction. Multiple SEPs, CCCs, and DCIs that blend and work together in several contexts will be needed to help students build toward competency in the targeted performance expectations. For example, if the end goal (the performance expectation) for students is to plan an investigation to determine the causes and effects of plant growth (2-LS2-1), they can build toward this goal through asking good questions about patterns that they have seen in plant growth and engaging in argument about what kinds of data would be important to collect in an investigation to answer these questions.

It should also be noted that one performance expectation should not be equated to one lesson. Performance expectations define the three-dimensional learning expectations for students, and it is unlikely that a single lesson would provide adequate opportunities for a student to demonstrate proficiency in every dimension of a performance expectation. A series of high-quality lessons or a unit in a program are more likely to provide these opportunities.

For more information about these three dimensions, see the NRC *Framework,* pages 29-33. Evaluating materials for three-dimensional learning is described in the EQuIP professional development module 6. Three-dimensional assessment of student learning is described in the document *Developing Assessments for the Next Generation Science Standards* (NRC 2014).

School programs must change:

From: providing discrete facts and concepts in science disciplines, with limited application of practice or the interconnected nature of the disciplines. Where crosscutting themes were included, they were implicit and not noticed or used by the student. Assessments within the programs exclusively addressed disciplinary concepts of science; neither the processes, inquiry, or SEPs nor the CCCs, unifying themes, or big ideas were included in the assessments.

To: providing learning experiences for students that blend multiple SEPs, CCCs, and DCIs — even those SEPs, CCCs, and DCIs not specified within the targeted performance expectations — with the goal that students are actively engaged in scientific processes to develop an understanding of each of the three dimensions. CCCs are included explicitly, and students learn to use them as tools to make sense of phenomena and make connections across disciplines. Assessments within the programs reflect each of the three distinct dimensions of science and their interconnectedness.

Innovation 2: Students engage in explaining phenomena and designing solutions.

In educational programs aligned to the NGSS, the goal of instruction is not solely for students to memorize content. Content becomes meaningful to students when they see its usefulness — when they need it to answer a question. Therefore, in programs aligned to the NGSS, an important component of instruction is to pique students' curiosity to help them see a need for the content.

The ultimate goal of an NGSS-aligned science education is for students to be able to explain real-world phenomena and to design solutions to problems using their understanding of the DCIs, CCCs, and SEPs. Students also develop their understanding of the DCIs by engaging in the SEPs and applying the CCCs. These three dimensions are tools that students can acquire and use to answer questions about the world around them and to solve design problems.

School programs must change:
From: focusing on disconnected topics, with content treated as an end in itself.
To: focusing on engaging students with meaningful phenomena or problems that can be explained or solved through the application of SEPs, CCCs, and DCIs. Instructional units that focus on students explaining relevant phenomena can provide the motivation students need to become invested in their own learning.

Innovation 3: The NGSS incorporate engineering design and the nature of science as SEPs and CCCs.

The NGSS include engineering design (see Appendices I and J) and the nature of science (see Appendix H) as significant elements. Some of the unique aspects of engineering design (e.g., identifying and designing solutions for problems), as well as common aspects of both science and engineering (e.g., designing investigations and communicating information), are incorporated throughout the NGSS as expectations for students from kindergarten through high school. In addition, unique aspects of the nature of science (e.g., scientific investigations use a variety of methods; scientific knowledge is based on empirical evidence; science is a way of knowing; science is a human endeavor) are included as SEPs and CCCs throughout the grade bands.

School programs must change:
From: presenting engineering design and the nature of science as supplemental or as disconnected from science learning (e.g., design projects that do not require science knowledge to complete successfully), with neither included in assessments.
To: incorporating learning experiences that include the DCIs of engineering design as well as the SEPs and CCCs of both engineering and the nature of science, with both included in assessments. Both engineering design and the nature of science are taught in an integrated manner with science disciplines (e.g., design projects require science knowledge in order to develop a good solution; the engineering process contributes to building science knowledge).

Innovation 4. SEPs, DCIs, and CCCs build coherent learning progressions from kindergarten to grade 12.

The NGSS provide for sustained opportunities from elementary through high school for students to engage in and develop a progressively deeper understanding of each of the three dimensions. Students require coherent learning progressions both within a grade level and across grade levels so they can continually build on and revise their knowledge to expand their understanding of each of the three dimensions by grade 12. See NGSS appendices E, F, and G for more information about the learning progressions for each dimension and how they build over time.

School programs must change:
From: a curriculum that lacks coherence in knowledge and experiences; provides repetitive, discrete knowledge that students memorize at each grade level; and often misses essential knowledge that has to be filled at later grade levels.
To: providing learning experiences for students that develop a coherent progression of knowledge and skills from elementary through high school. The learning experiences focus on a smaller set of disciplinary concepts that build on what has been learned in previous grades and provide the foundation for learning at the next grade span as detailed in the NGSS learning progressions.

Innovation 5. The NGSS connect to English language arts (ELA) and mathematics.

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The NGSS not only provide for coherence in science teaching and learning but also unite science with other relevant classroom subjects: mathematics and ELA. This connection is deliberate because science literacy requires proficiency in mathematical computations and in communication skills. In fact, there are many inherent overlaps in the mathematics, ELA, and science practices (e.g., see the Stanford Understanding Language Initiative's Venn diagram). Therefore as the NGSS were being drafted, the writers ensured alignment to and identified some possible connections with the Common Core State Standards for ELA/literacy and mathematics as an example of ways to connect the three subjects. In instruction within the science classroom, mathematical and linguistic skills can be applied and enhanced to ensure a symbiotic pace of learning in all content areas. This meaningful and substantive overlapping of skills and knowledge helps provide all students equitable with access to the learning standards for science, math, and literacy (e.g., see NGSS Appendix D Case Study 4). The fact that science can be connected to the "basics" should not go unnoticed. Indeed, it presents science as a basic!

School programs must change:
From: providing siloed science knowledge that students learn in isolation from reading, writing, and arithmetic — the historical "basic" knowledge.
To: providing science learning experiences for students that explicitly connect to mathematics and ELA learning in meaningful and substantive ways and that provide broad and deep conceptual understanding in all three subject areas.

Figure 2 summarizes the NGSS innovations and components for the reform of comprehensive school science programs.

Figure 2. NGSS Innovations and Design of Instructional Materials

FROM	TO	CHANGE IN SCHOOL PROGRAMS
Sole focus on discrete content	Integration of three dimensions (SEP, DCI, CCC)	Curriculum, instruction, and assessment
Learning content as the goal of lessons	Explaining phenomena through application of content as the goal of lessons	Curriculum and instruction
Engineering design and/or nature of science as supplemental	Engineering design and nature of science incorporated throughout science programs	Curriculum, instruction, and assessment
Concepts disconnected from prior learning	K–12 learning progressions	Curriculum, instruction, and assessment
Few connections to other subjects	Explicit connections to and alignment with ELA and mathematics	Curriculum and instruction

The implementation of NGSS-based reform has implications for all components of the school program and education system. The next sections discuss implications and recommendations for student materials, teacher materials and support, assessments within instructional materials, and how instructional materials can foster equitable opportunities to learn.

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NGSS AND KEY COMPONENTS OF SCIENCE INSTRUCTIONAL MATERIALS

The quality of science instructional materials depends on many different aspects of the materials. This document will not attempt to describe all the important criteria for quality — for example, adherence to accessibility standards for design of student materials is critical but is beyond the scope of this document. Instead, the key components of quality materials listed below are merely a potential second step to a review process that begins with the PEEC-Alignment evaluation. If sufficient evidence is found for the presence of the NGSS innovations in instructional materials, then additional criteria should be considered to aid in an evaluation of quality.

Student Materials

A quotation from the *Framework* sets the stage for this section.

The learning experiences provided for students should engage them with fundamental questions about the world and how scientists have investigated and found answers to those questions. Throughout grades K–12, students should have the opportunity to carry out scientific investigations and engineering design projects related to the disciplinary core ideas. (*A Framework for K-12 Science Education* 2012)

The first sentence makes it clear that the activities in student materials should focus on fundamental questions about real-world phenomena and engage students in SEPs as they develop answers and scientific knowledge related to those questions. Later, the *Framework* introduces the innovations that student instructional materials should incorporate to facilitate student learning of the three dimensions (i.e., SEPs, DCIs, and CCCs) and the processes and products of science and engineering. Here is an example from the *Framework:*

Instructional materials must provide a research-based, carefully designed sequence of learning experiences that develop students' understanding of the three dimensions and also deepen their insights in the ways people work to seek explanations about the world and improve the built world. (*A Framework for K-12 Science Education* 2012)

Contemporary themes of focus, rigor, and coherence can be used to summarize key features of high-quality student instructional materials.

Focus: Student materials should focus on the limited number of DCIs in the NGSS, not numerous disconnected factoids and details. Focus should be on the core ideas in the NGSS — those that are most important for all students to learn. This focus will allow more time for students and teachers to explore core ideas in greater depth, so they can engage in SEPs to achieve deeper understanding of real-world phenomena and to explore the practical use of engineering design.

Rigor: Student instructional materials should support rigorous instruction for each of the three dimensions to allow for conceptual understanding, procedural skills, and applications of the NGSS. Knowledge and practice must be intertwined in learning experiences to support the depth of understanding that is needed to engage in scientific inquiry and engineering design. Learning experiences must provide opportunities for thought, discourse, and practice in an interconnected and social context so that students develop deep conceptual understanding and the ability to evaluate knowledge claims.

Coherence: Student materials should provide strong links among the three dimensions of the NGSS within and between each unit, grade level, and grade span for a unified learning experience. Learning experiences should form a progression in which students actively engage in SEPs and apply

CCCs to continually build on and revise their knowledge and abilities in each field's DCIs over multiple years. Student materials must provide clear guidance that (1) helps teachers support students' engagement in science and engineering to develop explanations for phenomena and design solutions to problems and (2) helps students develop increasingly sophisticated ideas within a grade level and across grades K–12. Student science learning experiences must also align well to their learning in mathematics and ELA.

Additional key recommendations for student materials include the following:

A focus on the central idea behind each SEP, CCC, and DCI for the target grade level.

Support for learning experiences that facilitate three-dimensional learning (i.e., each of the three dimensions is learned in the context of the other two — not on its own). These three-dimensional learning experiences go beyond the specific combination of the three dimensions in an individual performance expectation.

Learning experiences that are framed by contexts that are engaging and meaningful to the students and are centered on real-world phenomena and design problems.

Coherent units and instructional sequences that introduce material in a logical manner, without requiring students to use concepts before they have been taught. For example, NGSS Appendix K describes some sample course arrangements for middle and high school that provide vertical coherence.

Grade level-appropriate learning experiences that explicitly involve the application of knowledge and skills learned in prior grades or earlier in the year.

Instructional sequences that provide multiple opportunities and contexts in which to explicitly encounter each idea (including each of the three dimensions) and skill, as well as adequate time to build toward student proficiency as described by the NGSS Evidence Statements by the end of the year or end of the unit.

Instructional sequences that have clear purposes for students' experiences (e.g., teach new knowledge, expose current misconceptions, build skills and abilities).

Learning goals (including for each of the three dimensions) that are explicit for students and provide opportunities for students to reflect on their learning.

Scientific accuracy and grade-level appropriateness.

Adherence to safety rules and regulations.

Thorough materials lists as needed. Such lists should identify expendable and permanent materials needed for both instruction and assessment.

High-quality (e.g., durable, dependable, functioning as intended) materials, equipment in kits, technological components, or online resources, where applicable.

Technological system requirements, where applicable.

Teacher Materials and Support

Teacher materials are a fundamental aspect of science classroom instruction. Components of teacher materials typically include annotated student texts, ancillary student materials designed to enhance or remediate, manuals of worksheets, yearly maps of content, suggestions for developing daily lessons, and lists of lab equipment used in the program. These components of the teacher materials have been and will continue to be useful for teachers in planning and supporting their instruction. However, the NRC's *Framework* and the subsequent NGSS have set a new vision of science education for K–12 students. This vision includes defining the knowledge and practices critical for understanding the natural world. The vision set forth by the NGSS and the NRC's *Framework* provides new challenges for those developing teacher materials. One challenge will be how to support teachers as they translate the new ideas into classroom practices. Research recognizes that expert teachers and leaders are perhaps the most important resources for improving student learning (Darling-Hammond 2000). Teacher materials will be necessary in this work but will need to be redesigned to facilitate both teacher understanding and ability to instruct their students.

NGSS-aligned instructional materials must focus on the three dimensions: SEPs, CCCs, and DCIs. Understanding each dimension and how they interact with each other will be critical for teachers as they begin to design instruction that intertwines and builds deeper understanding of the dimensions. Instructional materials developers can aid in increasing understanding of the three dimensions by providing ample annotations and suggestions on how to combine the three dimensions to engage students in developing explanations and constructing conceptual models of the natural world. Carefully planned authentic exploration of phenomena and a wide variety of instructional strategies will enable teachers to provide classroom experiences that will help students experience three-dimensional learning. In addition, the materials will need to develop articulated conceptual flows or learning progressions of content not only within each grade level but also across grade levels to aid the teacher's understanding and instruction of the three dimensions.

Some key ideas, strategies, and components to consider in developing instructional materials to aid teachers include the following:

Grade-appropriate background information for each of the three dimensions and an explanation of how the three disciplines interact within the grade, unit, and lesson levels.

A detailed yearlong map of the suggested learning progressions that could be used in planning the day-to-day instruction. Additionally, showing how the grade levels connect for coherence and build for greater sophistication of student understanding will be helpful.

Strategies that include appropriate and integral connections between science and other subject areas (e.g., mathematics, ELA, history/social science, visual and performing arts, career and technical education).

Guidance on strategies to interweave some of the "hands-on" practices (e.g., carrying out investigations, designing solutions) with science learning activities that use other practices (e.g., asking questions; engaging in argument; obtaining, evaluating, and communicating information) to bring about integrated instructional units.

Embedded instructional strategies throughout the instructional materials (e.g., scaffolding, note booking, think-pair-share, quick writes, open-ended questioning, cooperative learning, Socratic seminars, direct instruction, small-group instruction).

Strategies to identify the reason(s) that student may have difficulty in mastering or demonstrating their mastery of the three dimensions of the NGSS.

Strategies that effectively assess student knowledge and skills related to the three dimensions of the NGSS.

Strategies including alternative approaches and delivery mechanisms (e.g., computer-based instruction, web-based materials) that will assist in differentiating instruction to meet the needs of all students (e.g., English language learners, special needs students, advanced learners, struggling students) and adapt to different learning styles.

Strategies that help identify ways in which activities or learning experiences can be contextualized to the school environment.

An annotated list of resource materials, both expendable (e.g., cotton balls, pinto beans) and permanent (e.g., lab equipment), that are to be used throughout the program, including possible safety practices and room arrangements.

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Suggestions on types of professional development and learning experiences necessary for successful implementation.

Assessment in Instructional Materials

Classroom assessments are an integral part of instruction and learning and should include both formative and summative tasks. Formative tasks are those that are specifically designed to guide instructional decision making and lesson planning. Summative tasks are those that are specifically designed to assess student learning at the end of an instructional sequence, unit, grade level, or grade band (National Research Council 2014). Curriculum developers, assessment developers, and others who create resource materials aligned to the NGSS should ensure that assessment activities included in materials (such as formative assessment suggestions to teachers, mid- and end-of-chapter activities, tasks for unit assessments, and online activities) engage students in SEPs that demonstrate their understanding of DCIs and CCCs. These assessment materials also should reflect multiple dimensions of diversity (e.g., by connecting with students' cultural and linguistic identities). In designing instructional materials that include formative and summative assessments, development teams should include experts in science, science learning, assessment design, equity, diversity, and science teaching (National Research Council 2014).

Assessment tasks must be designed to provide evidence of students' ability to use the SEPs, to apply their knowledge of CCCs, and to draw on their understanding of DCIs, all in the context of addressing specific problems or answering certain questions (National Research Council 2014). Instruction and assessments must be designed to support and monitor students as they develop increasing sophistication in their ability to use SEPs, apply CCCs, and understand DCIs as they progress through the year and across the grade levels. An example of creating and assessing these smaller scale learning goals can be found in "Planning Instruction to Meet the Next Generation Science Standards" (Krajcik et al. 2014). Assessment developers should draw on the idea of developing understanding as they structure tasks for different levels and purposes and build this idea into the scoring rubrics for the tasks (National Research Council 2014). Although factual knowledge is fundamental and understanding the language and terminology of science is very important, tasks that demand only declarative knowledge about practices or isolated facts would be insufficient to measure performance expectations in the NGSS (National Research Council 2014).

Effective evaluation of three-dimensional science learning requires more than a one-to-one mapping between the NGSS performance expectations and assessment tasks. It is important to note that more than one assessment task may be required to adequately assess students' mastery of some performance expectations, and any given assessment task may assess aspects of more than one performance expectation. In addition, to assess both understanding of core knowledge and facility with a practice, assessments may need to probe students' use of a given practice in more than one disciplinary context. To adequately cover the three dimensions, assessment tasks will generally need to contain multiple components (e.g., a set of interrelated questions). Developers might focus on individual SEPs, DCIs, or CCCs in some components of an assessment task, but together, the components need to support inferences about students' three-dimensional science learning as described in a given performance expectation. Assessment tasks that attempt to test practices in strict isolation likely will not be as meaningful as assessments of the three-dimensional science learning called for by the NGSS (National Research Council 2014).

Key points regarding classroom assessments to support the NGSS:

Assessments are aligned with the NGSS; are authentic; and include pre-assessments, formative assessments, summative assessments, and self-monitoring measures.
Assessments collect data on all three dimensions of the NGSS and on how the students are using the different dimensions in concert with one another.
Assessments have explicitly stated purposes and are consistent with the decisions they are designed to inform.
Assessments are embedded throughout instruction materials as tools for students' learning and teachers' monitoring of instruction.
Assessments reflect only knowledge and skills that have been covered adequately in the instructional materials.
Assessments use varied methods, language, representations, and examples that are unbiased and accessible to all students and provide teachers with a range of data to inform instruction.

For more information regarding classroom assessment and the NGSS, see the following in the NRC's report, *Developing Assessments for the Next Generation Science Standards* (2014):
Chapter three provides in-depth information about how to design NGSS- appropriate assessment tasks and includes examples.
Chapter four illustrates the types of assessment tasks that can be used in the classroom to meet the goals of the NRC's *Framework* and the NGSS.

Equitable Opportunity to Learn in Instructional Materials

The NGSS offer a vision of science teaching and learning that presents both opportunities and demands for ALL students. The NGSS highlight issues related to equity and diversity and offer specific guidance for fostering science learning for diverse groups (see NGSS, Appendix D). Issues related to equity and diversity become even more important when standards are translated into curricular and instructional materials and assessments. Opportunity to learn is a crucial component in the design of resources and includes instructional time, equipment, materials, and well-prepared teachers. Instructional resources should support teachers in meeting the needs of diverse students and in identifying, drawing on, and connecting with the advantages their diverse experiences give them for learning science (National Research Council 2014). The focus on engaging real-world phenomena and design problems offers multiple entry points to build and deepen understanding for all students. The SEPs offer rich opportunities for language learning while they support science learning for all students (National Research Council 2012).

All students bring their own knowledge and understanding about the world when they come to school. Their knowledge and understanding is based on their experiences, culture, and language (National Research Council 2007). Their science learning will be most successful if curriculum, instruction, and assessments draw on and connect with these experiences and are accessible to students linguistically and culturally (Rosebery et al. 2010; Rosebery and Warren 2008; Warren and Ogonowski 2005; Warren, Ballenger, et al. 2001; National Research Council 2014). Researchers who study English language learners also stress the importance of a number of strategies for engaging those students, and they note that these strategies can be beneficial for all students. For example, techniques used in literacy instruction can be used in the context of science learning. These strategies promote comprehension and help students build vocabulary so they can learn content at high levels while their language skills are developing (Lee and Maerten-Rivera 2012; Lee, Quinn, and Valdez 2013; National Research Council 2014).

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Key points regarding instructional materials that support equitable opportunity to learn the NGSS:

The materials provide guidance for teaching diverse student groups, including visually impaired students, hearing impaired students, students with special needs, talented and gifted students, and English language learners.

Students have adequate opportunities to demonstrate their understandings and abilities in a variety of ways and appropriate contexts.

The focus phenomena for each course, unit, or lesson are chosen carefully, taking into account the interest and prior experiences of diverse students. When phenomena are not relevant or clear to some students (e.g., crop growth on farms), alternate engaging phenomena are suggested to the teacher.

The materials provide extensions consistent with the learning progression for students with high interest or who have already met the performance expectations. The NGSS assessment boundaries are intended to limit large-scale assessment and not to limit extension opportunities for students.

The texts recognize the needs of English language learners and help them both access challenging science and develop grade-level language. For example, materials might include annotations to help with comprehension of words, sentences, and paragraphs and give examples of the use of words in other situations. Modifications to language should neither sacrifice the science content nor avoid necessary language development.

The language used to present scientific information and assessments is carefully considered and should change with the grade level and across science content.

The materials provide the appropriate reading, writing, listening, and/or speaking modifications (e.g., translations, front-loaded vocabulary word lists, picture support, graphic organizers) for students who are English language learners, have special needs, or read below the grade level.

The materials provide extra support for students who are struggling to meet the performance expectations.

For more information regarding equitable learning opportunities, research-based strategies for effective implementation, context for student diversity, and the NGSS, see the following:

Next Generation Science Standards Appendix D, "All Standards, All Students."

Seven case studies that illustrate science teaching and learning of nondominant student groups as they engage in the NGSS.

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504 PLAN STUDENTS

Students who are eligible for accommodations or modifications under Section 504 of the Rehabilitation Act of 1973 may not be classified as special education, but have an impairment of a major life function such as performing manual tasks, walking, seeing, hearing, speaking etc. Any accommodations or modifications for Section 504 eligible students must be specified in the student's accommodation plan and must be consistent with the instruction and assessment procedures in the classroom.

LIMITED-ENGLISH PROFICIENT

All Limited-English Proficient (LEP) students must take the New Jersey statewide assessments and may be tested with one or more accommodations in the test administration procedure. These accommodations may include:
Additional time up to 150% of the administration times indicated;
Translation of the test directions only into the student's native language; and
Use of a Bilingual translation dictionary.

ACCOMMODATIONS, MODICIFATIONS, AND INTERVENTIONS

An accommodation can be made for any student, not just students with a 504 plan or an IEP. An accommodation does not alter what the student is expected to learn. An accommodation makes learning accessible to the student and allows the student to demonstrate what they know.
Accommodations are alterations in the way tasks are presented that allow children with a disability to complete the same assignments as other children.
Accommodations do not alter the content of assignments, give students an unfair advantage or in the case of assessments, change what a test measures. They do make it possible for students with LD to show what they know without being impeded by their disability.
Accommodations are basically physical or environmental changes, generally referred to as good teaching strategies.

- Extended time, frequent breaks, varying of activities

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• Change in classroom, preferential seating, physical arrangement of the room, reducing/minimizing distractions, cooling off period
• Emphasizes varied teaching approaches (visual, auditory, multi-sensory), individual or small group, demonstrating/modeling, visual cues, use of manipulatives, pre-teaching, graphic organizers
• Highlighting material, note taking assistance, notes provided by teacher, calculator, computer, word processor, Braille, and/or large print
• Directions given in small, sequential steps, copying from book
• Positive reinforcement, concrete reinforcement, checking for understanding, study guides, before/after school tutoring
• Reading test verbatim, shortening length of test, test format changed (multiple choice vs. fill in the blank)
• Allow for verbal responses

Should accommodations have an impact on how assignments are graded?
School assignments and tests completed with accommodations should be graded the same way as those completed without accommodations. After all, accommodations are meant to "level the playing field," provide equal and ready access to the task at hand, and not meant to provide an undue advantage to the user.

What if accommodations don't seem to be helping? Selecting and monitoring the effectiveness of accommodations should be an ongoing process, and changes (with involvement of students, parents and educators) should be made as often as needed. The key is to be sure that chosen accommodations address students' specific areas of need and facilitate the demonstration of skill and knowledge.

<u>MODIFICATIONS</u>
Modifications are generally made for students with significant cognitive or physical disabilities. A modification does alter content knowledge expectations as well as assessment administration practices. A modification is a change in the course of study, standards, test preparation, location, timing, scheduling, expectations, student response and/or other attribute which provide access for a student with a disability to participate in a course, standard or test. It does fundamentally alter or lower the standard or expectation of the course, standard or test.

Modifications are used in the classroom to meet the needs of every child's strength.

<u>Modifications involve lowering the level of materials presented.</u>
• Presentation of curriculum is modified using a specialized curriculum which is written at a lower level of understanding.
• Materials are adapted; texts are simplified by modifying the content areas—simplifying vocabulary, concepts and principles.
• Grading is subject to different standards than general education, such as based on IEP goals.
• Assignments are changed using lower level reading levels, worksheets and simplified vocabulary.
• Testing Adaptations are used, such as lowering the reading level of the test.

<u>Accommodations vs. Modifications</u>

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Accommodations level the playing field while Modifications change the field you're playing on.

- Decisions must be based on the child's unique and individualized need, not on what we do for all kids with a particular classification.
- The use of accommodations or modifications should enable the child to demonstrate progress.
- Individual Education Plans should offer children equal opportunity for success.

INTERVENTIONS

An intervention is a specific skill-building strategy implemented and monitored to improve a targeted skill (i.e. what is actually known) and achieve adequate progress in a specific area (academic or behavioral). This often involves a changing instruction or providing additional instruction to a student in the area of learning or behavior difficulty.
Academic or behavior interventions are strategies or techniques applied to instruction in order to teach a new skill, build a fluency skill, or encourage the application of existing skills to a new situation.
Interventions require a targeted assessment, planning, and date collection. Interventions should be evidence based and monitored regularly to determine growth and to inform instruction.

Interventions differ from accommodations and modifications in that they teach new skills to help students overcome specific deficits or maladaptive response patterns.
Interventions require a targeted assessment, planning, and data collection (ideally including baseline data) to be effective. Consideration is given to the nature of the problem (i.e. skill deficit versus performance deficit).
Interventions focus on the needs of the "individual" student.

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ACCOMMODATIONS, INTERVENTIONS, MODIFICATIONS CHART

Accommodations	Interventions	Modifications
Accommodate is defined as “to make fit.” It is similar to adaptation. Accommodations and adaptations are used to describe how students are included in classroom instruction. Changes to the classroom structure, both organizationally and instructionally that allows a student to participate.	An intervention is defined as “to come between.” Doctors use medications for intervention. Medications are used to intervene with a fever to change the body temperature. Teachers use strategies to change a student’s learning outcomes.	Modify is defined as “to alter; to make different in form” … “to change to less extreme” Most often associated with IDEA. Students receiving special education services. Teachers use modifications of grade level standards, strategies, curriculum and assessments to create a learning environment for a specific student
Using grade level curriculum standards via a different path – think differentiated. Adaptations to the regular curriculum to make it possible for the child to be successful at benchmark	Additions to the curriculum to designed to help a student make progress toward benchmarks.	Change in curriculum standards. Change in core program; use of a parallel curriculum that does not include all grade level standards Designates different benchmarks.
Levels the “Playing Field”	Ensures the “Playing Field”	Creates the “Playing Field”
Changes something about the child's environment or services provided. A change that helps a student overcome or work around a learning problem.	Teaches the student a new skill. Teaches the student a strategy to use when applying a skill.	A change in what is being taught to or expected from the student.
Preferential seating	Mini-lessons of skill deficits	Student is involved in the same theme/unit but is provided different tasks/expectations
Shortened assignments	Targeted instruction based on progress monitoring	Individualized materials are provided for student
Peer-tutoring	Additional instruction to students in small groups or individually	Eliminate specific standards
Moving obstacles in a classroom so that a student with a wheelchair could navigate the classroom.	Increase task structure (e.g., directions, rationale, checks for understanding, feedback)	Create individualized benchmarks
Classroom level: seating	Increase opportunities to engage in	

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arrangements, note talking, outline/study guides, tape recorders, etc.	active academic responding (e.g., writing, reading aloud, answering questions in class, etc.)	
Repeat/confirm directions	Multi-sensory techniques	
Additional time to complete assignment	Familiar Reading activities for fluency	
Audio tape	Speed sorts of ABCs, sight words	
Reduce the number of items per page or line	Build automaticity with known information, letters, words, phonetic patterns	
Provide a designated reader	Follow up reading with story frame activities: story summary, important ides or plot, setting, character analysis and comparison	
Present instructions orally	Model metacognition	
Allow for verbal responses	Utilize pre-reading strategies and activities: previews, anticipatory guides, and semantic mapping	
Allow for answers to be dictated	Use reciprocal teaching to promote comprehension and comprehension monitoring: predicting, question generating, summarizing and clarifying	
Permit response provided via computer or electronic device	Underline word and phrase clues that lead to making an inference	
Allow frequent breaks	Echo reading: the student imitates the teacher's oral rendition, one sentence or phrase at a time	
Extend allotted time for tests		
Provide a place with minimal distractions		
Administer tests in several sessions		
Administer tests at a specific time		

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of day		
Provide special test preparation		

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21st-CENTURY LIFE & CAREERS—New Jersey Core Curriculum Content Standards

In the 21st century, life and work are conducted in a dynamic context that includes:
• A global society facing complex political, economic, technological, and environmental challenges
• A service economy driven by information, knowledge, and innovation
• Diverse communities and workplaces that rely on cross-cultural collaborative relationships and virtual social networks
• An intensely competitive and constantly changing worldwide marketplace Providing New Jersey students with the life and career skills needed to function optimally within this dynamic context is a critical focus and organizing principle of K-12 public education. New Jersey has both an obligation to prepare its young people to thrive in this environment, and a vested economic interest in grooming an engaged citizenry made up of productive members of a global workforce that rewards innovation, creativity, and adaptation to change.

Mission: 21st-century life and career skills enable students to make informed decisions that prepare them to engage as active citizens in a dynamic global society and to successfully meet the challenges and opportunities of the 21st-century global workplace.

Vision: The systematic integration of 21st-century life and career skills across the K-12 curriculum and in career and technical education programs fosters a population that:
• Applies critical thinking and problem-solving skills to make reasoned decisions at home, in the workplace, and in the global community.
• Uses effective communication, communication technology, and collaboration skills to interact with cultural sensitivity in diverse communities and to work in cross-cultural teams in the multinational workplace.
• Is financially literate and financially responsible at home and in the broader community.
• Demonstrates creative and entrepreneurial thinking by recognizing and acting on promising opportunities while accepting responsibility for possible risks.
• Is knowledgeable about careers and can plan, execute, and alter career goals in response to changing societal and economic conditions.
• Produces community, business, and political leaders who demonstrate core ethical values, including the values of democracy and free enterprise, during interactions with the global community.

Intent and Spirit of the 21st-Century Life and Career Standards
Through instruction in life and career skills, all students acquire the knowledge and skills needed to prepare for life as citizens and workers in the 21st century.
• In Preschool, children's social and emotional development provides the foundation for later learning about careers and life skills (http://www.nj.gov/education/ece/code/expectations/).
• In grades K-5, students are introduced to 21st-century life skills that are critical for personal, academic, and social development. They are also introduced to career awareness information and to basic personal financial literacy skills.
• In grades 6-8, students continue to develop 21st-century life skills and personal financial literacy, while also exploring careers that support their academic and personal interests and

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aptitudes. As they prepare for the transition to high school, students are provided with opportunities to apply knowledge and skills learned in the classroom to real or simulated career challenges.

• In grades 9-12, students develop increasingly sophisticated 21st-century life skills and personal financial literacy. They engage in the process of career preparation by participating in structured learning experiences, specialized programs, and advanced courses that reflect personal aptitudes and career interests found within one or more of the 16 career clusters developed by the States Career Clusters Initiative.

<u>The Revised Standards</u>

There are four revised 21st-Century Life and Careers standards. Standards 9.1, 9.2, and 9.3 describe life and career skills that are integrated throughout the K-12 curriculum, while Standard 9.4 describes specialized skills that are taught in grades 9-12 as part of career and technical education programs. An overview of the four standards follows.

Standard 9.1 21st-Century Life and Career Skills: All students will demonstrate the creative, critical thinking, collaboration, and problem-solving skills needed to function successfully as both global citizens and workers in diverse ethnic and organizational cultures. Standard 9.1 describes skills that prepare students to fully engage in civic and work life. The standard includes six strands, which reflect the Framework for 21st Century Learning:

• Critical Thinking and Problem Solving
• Creativity and Innovation
• Collaboration, Teamwork, and Leadership
• Cross-Cultural Understanding and Interpersonal Communication
• Communication and Media Fluency
• Accountability, Productivity, and Ethics

Standard 9.2 Personal Financial Literacy: All students will develop skills and strategies that promote personal and financial responsibility related to financial planning, savings, investment, and charitable giving in the global economy. Standard 9.2 describes skills that prepare students for personal and civic financial literacy. The inclusion of Personal Financial Literacy as a standard, rather than as a strand, reflects the growing need for 21stcentury citizens to be financially literate, particularly in light of the increasing number of financial choices they face due to the global economy. Financial literacy includes the application of knowledge, skills, and ethical values when making consumer and financial decisions that impact the self, the family, and the local and global communities. Standard 9.2 is aligned to the Jump $tart Coalition for Personal Financial Literacy's National Standards in K-12 Personal Finance Education and includes seven strands:

• Income and Careers
• Money Management
• Credit and Debt Management
• Planning, Saving, and Investing
• Becoming a Critical Consumer
• Civic Financial Responsibility
• Risk Management and Insurance

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Standard 9.3 Career Awareness, Exploration, and Preparation: All students will apply knowledge about and engage in the process of career awareness, exploration, and preparation in order to navigate the globally competitive work environment of the information age. Standard 9.3 describes skills that prepare students for career pursuits and lifelong learning. The three strands in Standard 9.3 reflect the requirements outlined in New Jersey Administrative Code (N.J.A.C. 6A:8-3.2):

• Career Awareness (grades K-4)
• Career Exploration (grades 5-8)
• Career Preparation (grades 9-12)

Standard 9.4 Career and Technical Education: All students who complete a career and technical education program will acquire academic and technical skills for careers in emerging and established professions that lead to technical skill proficiency, credentials, certificates, licenses, and/or degrees. Standard 9.4 describes knowledge and skills that prepare students for postsecondary education, training, and employment in a chosen career pathway. Unlike Standards 9.1, 9.2, and 9.3, which apply to all students from grades K-12, Standard 9.4 applies only to high school students enrolled in career and technical education programs.

The adoption of the career and technical education standard reflects the call to action in recent reports by the National Association of State Boards of Education, the National Governors Association, the U.S. Chamber of Commerce, and Achieve regarding the potential of career and technical education, as well as the requirements of the Carl D. Perkins Career and Technical Education Improvement Act of 2006. These documents urge states to adopt policies and practices that effectively integrate academic content standards in career and technical education programs in order to both elevate the role of career and technical education and to align it with postsecondary education and training.

The 16 strands in Standard 9.4 align with the 16 career clusters of the States Career Clusters Initiative.
Each strand is further refined to reflect multiple career pathways. By using the clusters as an organizing tool for grouping occupations and careers, Standard 9.4 identifies a common set of knowledge and skills for success within each broad career cluster, as well as for each career pathway within that cluster. This framework has been reviewed nationally by teams of business, industry, labor, education, and higher education representatives to ensure that it encompasses industry-validated knowledge and skills needed for career success.

For each of the 16 career cluster strands, content statements and cumulative progress indicators are provided for the overall career cluster, and additional content statements and cumulative progress indicators are provided for each of the career pathways encompassed by the cluster. Further, each of the 16 overarching career cluster strands is comprised of two types of cumulative progress indicators:

• Cumulative progress indicators for foundational knowledge and skills, which may be taught as part of a variety of academic and/or career and technical education courses.
• Cumulative progress indicators that are specific to the career cluster and/or career pathway under discussion. Two additional resources are provided in connection with Standard 9.4 to

support navigation of Standard 9.4 and understanding of career and technical education (CTE) programs:
• The Career Clusters Table describes each of the 16 career clusters and lists the career pathways associated with each cluster.
• More About CTE Programs provides a definition of career and technical education programs and points to information about the development of Standard 9.4.

TECHNOLOGY—New Jersey Student Learning Standards

New Jersey's Technology Standards consist of 8.1 Educational Technology and 8.2 Technology, Engineering, Design and Computational Thinking, which work symbiotically to provide students with the necessary skills for college and career readiness.
"Advances in technology have drastically changed the way we interact with the world and each other. The digital age requires that we understand and are able to harness the power of technology to live and learn". - International Society for Technology in Education
In this ever-changing digital world where citizenship is being re-imagined, our students must be able to harness the power of technology to live, solve problems and learn in college, on the job and throughout their lives. Enabled with digital and civic citizenship skills, students are empowered to be responsible members of today's diverse global society.
Readiness in this century demands that students actively engage in critical thinking, communication, collaboration, and creativity. Technology empowers students with real-world data, tools, experts and global outreach to actively engage in solving meaningful problems in all areas of their lives. The power of technology discretely supports all curricular areas and multiple levels of mastery for all students.
"A major consequence of accelerating technological change is a difference in levels of technological ability and understanding. The workforce of the future must have the ability to use, manage, and understand technology." – International Technology and Engineering Educators Association
The design process builds in our students the recognition that success is not merely identifying a problem but working through a process and that failure is not an end but rather a point for reevaluation. Whether applied as a skill in product development, in the learning environment, in daily life, in a local or more global arena, the design process supports students in their paths to becoming responsible, effective citizens in college, careers and life.
Computational thinking provides an organizational means of approaching life and its tasks. It develops an understanding of technologies and their operations and provides students with the abilities to build and create knowledge and new technologies. Not all students will be programmers, but they should have an understanding of how computational thinking can build knowledge and control technology.
INTERNATIONAL SOCIETY FOR TECHNOLOGY IN EDUCATION (ISTE) STANDARDS
Empowered Learner—Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences.
1a Students articulate and set personal learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process itself to improve learning outcomes.

1b Students build networks and customize their learning environments in ways that support the learning process.
1c Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.
1d Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfertheir knowledge to explore emerging technologies.

Digital Citizen—Students recognize the rights, responsibilities and opportunities of living, learning and working in an interconnected digital world, and they act and model in ways that are safe, legal and ethical.
2a Students cultivate and manage their digital identity and reputation and are aware of the permanence of their actions in the digital world.
2b Students engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices.
2c Students demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property.
2d Students manage their personal data to maintain digital privacy and security and are aware of data-collection technology used to track their navigation online.
Knowledge Constructor—Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.
3a Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.
3b Students evaluate the accuracy, perspective, credibility and relevance of information, media, data or other resources.
3c Students curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
3d Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
Innovative Designer—Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.
4a Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
4b Students select and use digital tools to plan and manage a design process that considers design constraints and calculated risks.
4c Students develop, test and refine prototypes as part of a cyclical design process.
4d Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.
Computational Thinker—Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.
5a Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

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5b Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.
5c Students break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.
5d Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.
Creative Communicator—Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.
6a Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.
6b Students create original works or responsibly repurpose or remix digital resources into new creations.
6c Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.
6d Students publish or present content that customizes the message and medium for their intended audiences.
Global Collaborator—Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.
7a Students use digital tools to connect with learners from a variety of backgrounds and cultures, engaging with them in ways that broaden mutual understanding and learning.
7b Students use collaborative technologies to work with others, including peers, experts or community members, to examine issues and problems from multiple viewpoints.
7c Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.
7d Students explore local and global issues and use collaborative technologies to work with others to investigate solutions.

21st CENTURY LIFE & CAREERS—New Jersey Student Learning Standards

Career Ready Practices describe the career-ready skills that all educators in all content areas should seek to develop in their students. They are practices that have been linked to increase college, career, and life success. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study. Each Career Ready Practice includes an overarching statement along with a more detailed description. Below are the 12 overarching statements:
CPR1. Act as a responsible and contributing citizen and employee.

CRP2. Apply appropriate academic and technical skills.

CRP3. Attend to personal health and financial well-being.

CRP4. Communicate clearly and effectively and with reason.

CRP5. Consider the environmental, social and economic impacts of decisions.

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CRP6. Demonstrate creativity and innovation.

CRP7. Employ valid and reliable research strategies.

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

CRP9. Model integrity, ethical leadership and effective management.

CRP10. Plan education and career paths aligned to personal goals.

CRP11. Use technology to enhance productivity.

CRP12. Work productively in teams while using cultural global competence.

SCIENCE—NEW JERSEY CORE CURRICULUM CONTENT STANDARDS

5.1.A. Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world.

5.1.12.A.1 Content Statement
Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles.
Cumulative Progress Indicator (CPI) Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.

5.1.12.A.2 Content Statement
Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.
CPI Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.

5.1.12.A.3 Content Statement
Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence.
CPI Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.

5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims.

5.1.12.B.1 Content Statement
Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.
CPI Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data.

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5.1.12.B.2 Content Statement
Mathematical tools and technology are used to gather, analyze, and communicate results.
CPI Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.

5.1.12.B.3 Content Statement
Empirical evidence is used to construct and defend arguments.
CPI Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.

5.1.12.B.4 Content Statement
Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.
CPI Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.

5.1.C REFLECT ON SCIENTIFIC KNOWLEDGE: Scientific knowledge builds on itself over time.

5.1.12.C.1 Content Statement
Refinement of understandings, explanations, and models occurs as new evidence is incorporated.
CPI Reflect on and revise understandings as new evidence emerges.

5.1.12.C.2 Content Statement
Data and refined models are used to revise predictions and explanations.
CPI Use data representations and new models to revise predictions and explanations.

5.1.12.C.3 Content Statement
Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges.
CPI Consider alternative theories to interpret and evaluate evidence-based arguments.

5.1.D PARTICIPATE PRODUCTIVELY IN SCIENCE: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms

5.1.12.D.1 Content Statement
Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.
CPI Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.

5.1.12.D.2 Content Statement
Science involves using language, both oral and written, as a tool for making thinking public.
CPI Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.

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5.1.12.D.3 Content Statement
Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically.
CPI Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.

5.2 Physical Science All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

5.2.A Properties of Matter: All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia.

5.2.12.A.1 Content Statement
Electrons, protons, and neutrons are parts of the atom and have measurable properties, including mass and, in the case of protons and electrons, charge. The nuclei of atoms are composed of protons and neutrons. A kind of force that is only evident at nuclear distances holds the particles of the nucleus together against the electrical repulsion between the protons.
CPI Use atomic models to predict the behaviors of atoms in interactions.

5.2.12.A.2 Content Statement
Differences in the physical properties of solids, liquids, and gases are explained by the ways in which the atoms, ions, or molecules of the substances are arranged, and by the strength of the forces of attraction between the atoms, ions, or molecules.
CPI Account for the differences in the physical properties of solids, liquids, gases.

5.2.12.A.3 Content Statement
In the Periodic Table, elements are arranged according to the number of protons (the atomic number). This organization illustrates commonality and patterns of physical and chemical properties among the elements.
CPI Predict the placement of unknown elements on the Periodic Table based on their physical and chemical properties..

5.2.12.A.4 Content Statement
In a neutral atom, the positively charged nucleus is surrounded by the same number of negatively charged electrons. Atoms of an element whose nuclei have different numbers of neutrons are called isotopes.
CPI Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes.

5.2.12.A.5 Content Statement
Solids, liquids, and gases may dissolve to form solutions. When combining a solute and solvent to prepare a solution, exceeding a particular concentration of solute will lead to precipitation of the

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solute from the solution. Dynamic equilibrium occurs in saturated solutions. Concentration of solutions can be calculated in terms of molarity, molality, and percent by mass.
CPI Describe the process by which solutes dissolve in solvents

5.2.12.A.6 Content Statement
Acids and bases are important in numerous chemical processes that occur around us, from industrial to biological processes, from the laboratory to the environment.
CPI Relate the pH scale to the concentrations of various acids and bases

5.2.12.B. Changes in Matter: Substances can undergo physical or chemical changes to form new substances. Each change involves energy.

5.2.12.B.1 Content Statement
An atom's electron configuration, particularly of the outermost electrons, determines how the atom interacts with other atoms. Chemical bonds are the interactions between atoms that hold them together in molecules or between oppositely charged ions
CPI Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form.

5.2.12.B.2 Content Statement
A large number of important reactions involve the transfer of either electrons or hydrogen ions between reacting ions, molecules, or atoms. In other chemical reactions, atoms interact with one another by sharing electrons to create a bond.
CPI Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel.

5.2.12.B.3 Content Statement
The conservation of atoms in chemical reactions leads to the ability to calculate the mass of products and reactants using the mole concept.
CPI Balance chemical equations by applying the law of conservation of mass.

5.2.12.C. Forms of Energy: Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable.

5.2.12.C.1 Content Statement
Gas particles move independently and are far apart relative to each other. The behavior of gases can be explained by the kinetic molecular theory. The kinetic molecular theory can be used to explain the relationship between pressure and volume, volume and temperature, pressure and temperature, and the number of particles in a gas sample. There is a natural tendency for a system to move in the direction of disorder or entropy.
CPI Use the kinetic molecular theory to describe and explain the properties of solids, liquids, and gases.

5.2.12.C.2 Content Statement

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Heating increases the energy of the atoms composing elements and the molecules or ions composing compounds. As the kinetic energy of the atoms, molecules, or ions increases, the temperature of the matter increases. Heating a pure solid increases the vibrational energy of its atoms, molecules, or ions. When the vibrational energy of the molecules of a pure substance becomes great enough, the solid melts.
CPI Account for any trends in the melting points and boiling points of various compounds.

5.2.D. Energy Transfer and Conservation: The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one object to another.

5.2.12.D.2 Content Statement
The driving forces of chemical reactions are energy and entropy. Chemical reactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).
CPI Describe the potential commercial applications of exothermic and endothermic reactions.

5.2.12.D.3 Content Statement
Nuclear reactions (fission and fusion) convert very small amounts of matter into energy. CPI Describe the products and potential applications of fission and fusion reactions.

5.2.12.D.4 Content Statement
Energy may be transferred from one object to another during collisions
CPI Measure quantitatively the energy transferred between objects during a collision

5.2.12.D.5 Content Statement
Chemical equilibrium is a dynamic process that is significant in many systems, including biological, ecological, environmental, and geological systems. Chemical reactions occur at different rates. Factors such as temperature, mixing, concentration, particle size, and surface area affect the rates of chemical reactions.
CPI Model the change in rate of a reaction by changing a factor.

STUDENT OUTCOMES

KNOWLEDGE (Information and Concepts)
The student will:
1. Design investigations, collect evidence, analyze data, and evaluate evidence to determine causal/correlational relationships and anomalous data. (5.1.12.B.1)
2. Develop an understanding of the relationships among facts, concepts, principles, theories, and models and use these relationships to understand phenomena in the natural world. (5.1.12.A.1)
3. Use tools, evidence, and data to observe, measure, and explain phenomena in the natural world. (5.1.12.A.2)
4. Construct and refine explanations, arguments or models of the natural world through the use of quantitative and qualitative evidence and data. (5.1.12.A.2)
5. Use scientific principles and theories to build and refine standards for data collection, posing controls, and representing evidence. (5.1.12.A.3)

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6. Build, refine, and represent evidence-based models using mathematical, physical and computational tools (5.1.12.B.2)
7. Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.(5.1.12.D.3)
8. Reflect on and revise understandings as new evidence emerges. (5.1.12.C.1)
9. Use data representations and new models to revise predictions and explanations. (5.1.12.C.2)
10. Revise predictions and explanations using evidence, and connect explanations/ arguments to established scientific knowledge, models and theories. (5.1.12.B.3)
11. Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (5.1.12.B4)
12. Consider alternative theories to interpret and evaluate evidence-based arguments. (5.1.12.C.3)
13. Engage in multiple forms of discussions in order to process, make sense of, and learn from others' ideas, observations, and experiences. (5.1.12.D.1)
14. Represent ideas using literal representations such as graphs, tables, journals, concept maps, and diagrams. (5.1.12.D.2)
15. Demonstrate either orally or in writing that he/she knows and understands the nature of chemistry as a study of matter, its structure, properties, and the changes it undergoes. (5.2.12.B)
16. Show proficiency in writing chemical formulas, naming compounds, and writing and balancing chemical equations.
17. Demonstrate in writing that he/she can solve problems using critical thinking in such areas as stoichiometry and the gas laws.
18. Communicate, verbally or in writing, a knowledge and understanding of the current atomic theory and of the classification of elements in the periodic table.
19. Explain the periodic trends in specific properties of elements, i.e. ionization energy, electronegativity, electron affinity, atomic and ionic radii using the Periodic Table.
20. Demonstrate a comprehension of the relationship between the type of bonding among atoms and the properties of the compounds formed, i.e. ionic, covalent, and metallic.
21. Demonstrate comprehension of kinetic theory and how energy is involved in the behavior of matter.
22. Show knowledge of chemical equilibrium, reaction rates, reaction mechanisms. acids, bases, and salts.
23. Write lab reports which indicate a comprehension of concepts learned in the classroom and applied in the laboratory.
24. Design experiments to solve a specific problem relating to chemical principles.
25. Build models and name common organic compounds such as hydrocarbons and simple polymers.
26. Distinguish between types of radiation and the energy associated with each
27. Describe the postulates of quantum theory.
28. Predict the products form4ed by common reactants, write and balance equations for the reactions.
29. Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes.
30. Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel

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31. Describe the products and potential applications of fission and fusion reactions

ATTITUDES

The student will:
1. Develop an appreciation for the study of chemistry and how it relates to his/her everyday life.
2. Research and investigate possible careers in chemistry.
3. Recognize the impact of chemistry on every aspect of daily life.

SKILLS AND BEHAVIORS

The student will:
1. Demonstrate good problem-solving techniques.
2. Write essays on specific topics in chemistry demonstrating comprehension of a given topic, i.e. the historical development of the Periodic Table, or atomic theory.
3. Demonstrate effective listening and note taking skills in lecture and discussion situations.
4. Demonstrate proper and safe use of laboratory equipment and chemicals during experiments.
5. Use the scientific method in solving laboratory based problems and writing reports based on their solutions.
6. Demonstrate in class discussion and in writing a comprehensive knowledge of chemical technology.
7. Write and balance equations for a variety of chemical reactions.
8. Work cooperatively in small groups to solve problems or perform experiments.
9. Design and interpret graphs using empirical and experimental data.
10. Use spreadsheet and graphing software to report results of laboratory investigations.
11. Design and produce presentations using Power Point presentation software.
12. Set up and perform experiments using computer interfaced sensors to collect data.
13. Use internet search engines to locate chemistry related websites for research and review.
14. be aware of the connection between educational activities and the world of work

STRATEGIES

The following strategies/activities will be used:
NOTE: The suggested activities provided in this document are ideas for the teacher. If the teacher chooses to develop his/her own activity, *it must be of equal or better quality and at the same or higher cognitive levels.*
• Audio visual media
• Charts, handouts, graphs
• Class & individual assignments
• Cooperative activities
• Critical thinking:
• Decision making
• Compare & contrast
• Reliable sources
• Causal explanation
• Prediction
• Debates & panel discussion

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• Demonstrations (teacher/student led)
• Direct instruction
• Discussion (teacher/student led)
• Drill practice
• Extra credit project or presentation
• Homework
• Investigation
• Laboratory experiment
• Lecture
• Library and resource documents
• Oral reading
• Periodicals
• Questioning techniques
• Research paper
• Reviews
• Self-instructional instruments
• Textbook: Wilbraham, Chemistry, 2008. Pearson
• Textbook supplements
• Tutoring (peer & teacher)

EVALUATION

NOTE: Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.

Assessments may include

DERIVED ASSESSMENT *inferred from student's ability to respond to items on paper*.
• Tests
• Quizzes
• Homework
• Benchmark assessment

AUTHENTIC ASSESSMENT *based on behavior, product, or outcome*.
• Class participation
• Teacher observation
• Infusion exercises
• Portfolios
• Varied approach projects

PERFORMANCE ASSESSMENT *authentic assessment specific to chemistry*.
• Laboratory

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AP Chemistry

11th & 12th Grades

Prepared by
Steve Nagiewicz, Ahmed Khan Barbara Hamill, George Quinn & Kevin Corcoran
Reviewed by
Supervisor of Science

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Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

(Revised July 2018)

I. OVERVIEW

Chemistry introduces the student to the study of matter, its composition and structure, and the changes it may undergo. A study of the structure of the atom combined with periodic law leads to an understanding of the organization of the elements in the periodic table. This knowledge of the atom and the organization of the elements is used to develop concepts of ionic, covalent and metallic bonding among atoms as well as to write formulas for compounds and equations to represent chemical reactions. Phases of matter will be studied and will include an introduction to gas laws, water, aqueous systems and solutions, The course will also incorporate the study of Thermochemistry including the concept of heat flow and the relationship between heat and temperature and rates of reactions and equilibrium. Properties of acids and bases will be introduced.

II. RATIONALE

This course is developed for the student who wishes to have a basic understanding of chemistry as an integral part of the study of nature and as a preparation for advanced science courses. . Additionally, an understanding of the scientific process, scientific method, and rational thinking skills is essential for students to sort and evaluate incoming information.

III. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

- 5.1 All students will develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.
- 5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.
- 5.3 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.
- 5.4 All students will understand the interrelationship between science and technology and develop a conceptual understanding if the nature and process of technology.
- 5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.

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5.6 All students will gain an understanding of the structure and behavior of matter.

5.7 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.

5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.9 All students will gain an understanding of the origin, evolution, and structure of the universe.

5.10 All students will develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.

IV. STUDENT OUTCOMES

A*. KNOWLEDGE (Information and Concepts)*

The student will:

1. demonstrate either orally or in writing that he/she knows and understands the nature of chemistry as a study of matter, its structure, properties, and the changes it undergoes. [8.1,8.2, 5.1.A, 5.2.1, 5.2.B, 5.7.A, 5.8]*
2. show proficiency in writing chemical formulas, naming compounds, and writing and balancing chemical equations. [8.1, 5.1.A, 5.1.B, 5.3, 5.6.B]
3. demonstrate in writing that he/she can solve problems using critical thinking in such areas as stoichiometry and the gas laws. [8.1, 5.1.A,5.1.B, 5.3, 5.6, 5.8.B]
4. communicate, verbally or in writing, a knowledge and understanding of the current atomic theory and of the classification of elements in the periodic table. [8.1, 5.2, 5.6.A, 5.8.A]
5. using the Periodic Table, explain the periodic trends in specific properties of elements, i.e. ionization energy, electronegativity, electron affinity, atomic and ionic radii. [8.1, 5.6.A, 5.8.A, 5.7.B]
6. demonstrate a comprehension of the relationship between the type of bonding among atoms and the properties of the compounds formed, i.e. ionic, covalent, metallic. [8.1, 5.6, 5.7.B, 5.1.A, 5.1.B]
7. demonstrate comprehension of kinetic theory and how energy is involved in the behavior of matter. [8.1, 5.6, 5.7.B, 5.3.B-D]
8. show knowledge of chemical equilibrium, reaction rates, reaction Mechanisms. acids, bases, and salts. [8.1, 5.6.B, 5.3, 5.4]
9. write lab reports which indicate a comprehension of concepts learned in the classroom and applied in the laboratory. [8.2,8.1, 5.4, 5.1, 5.3]
10. design experiments to solve a specific problem relating to chemical principles. [8.1, 5.4, 5.3, 5.1]
11. build models and name common organic compounds such as hydrocarbons and simple polymers. [8.1, 5.4, 5.3, 5.5.A, 5.6.A]
12. distinguish between types of radiation and the energy associated with each. [8.1, 5.7.B, 5.8.A, 5.10.B]
13. define and distinguish between entropy and enthalpy. [8.1, 5.7.B, 5.10.A, 5.6.B]
14. describe the postulates of quantum theory. [5.1.A, 5.7.B, 5.6.A]
15. predict the products formed by common reactants, write and balance equations for the reactions. [8.1, 5.6.B, 5.1.A]

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16. Demonstrate knowledge of properties of acids, bases and salts.[8.1, 5.6.B, 5.3, 5.4]

B. ATTITUDES

The student will:
1. develop an appreciation for the study of chemistry and how it relates to his/her everyday life. [8.1,8.2, 5.1, 5.2, 5.4.A, 5.10.B]
2. research and investigate possible careers in chemistry. [9.1, 9.2, 8.1,8.2,8.6, 5.2, 5.4, 5.10]
3. recognize the impact of chemistry on every aspect of daily life. [8.1, 8.2, 5.1, 5.2, 5.4.A, 5.10.B]

C. SKILLS AND BEHAVIORS

The student will:
1. demonstrate good problem-solving techniques. [8.1,8.2, 5.1, 5.3, 5.4]
2. write essays on specific topics in chemistry demonstrating comprehension of a given topic, i.e. the historical development of the Periodic Table, or atomic theory. [8.1, 5.1, 5.2, 5.6]
3. demonstrate effective listening and note taking skills in lecture and discussion situations. [8.1, 5.1.A]
4. demonstrate proper and safe use of laboratory equipment and chemicals during experiments. [8.1, 5.1.C, 5.1.A]
5. use the scientific method in solving laboratory based problems and writing reports based on their solutions. [8.1, 5.1 A, 5.1 B]
6. demonstrate in class discussion and in writing a comprehensive knowledge of chemical technology. [8.1, 5.1.A, 5.1.B, 5.4]
7. write and balance equations for a variety of chemical reactions. [8.1, 5.1.A, 5.6.B]
8. work cooperatively in small groups to solve problems or perform experiments. [8.1, 5.1.A, 5.1.B]
9. design and interpret graphs using empirical and experimental data. [8.1,8.2, 5.4, 5.1]
10. use spreadsheet and graphing software to report results of laboratory investigations. [8.1,8.2, 5.4, 5.1)
11. design and produce presentations using Power Point presentation software. [8.1, 5.4]
12. set up and perform experiments using computer interfaced sensors to collect data. [8.1,8.2, 5.4, 5.1)
13. utilize Internet search engines to locate chemistry related websites for research and review. [8.1,8.2]
14. be aware of the connection between educational activities and the world of work [9.1, 9.2]

IV. STRATEGIES

The following strategies/activities will be used:

Interactive lectures

Problem solving activities
Power point presentations
Labs
Group work
Use of computer interfaced data collection sensors

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Peer review
Make the appropriate accommodations for special needs and ELL students
- Additional time and other IEP stated accommodations
- Audio text resources
- Varied assessments

IV. EVALUATION

Assessments may include

Tests and quizzes
Lab reports

Laboratory practicum
Homework
Other class work
Notebook evaluation
Class participation
Student projects
Computer driven spreadsheets and graphs
Oral and/or Power Point presentations
Students will also be expected to design and execute projects and/or original research.

VI. REQUIRED RESOURCES

Students Resources

Textbook:- **General Chemistry Principles and Modern Applications** 8th Ed (2006)
Laptop Cart
Microsoft office
CD-Rom Chemistry
Internet resources
Virtual Labs

VII. SCOPE AND SEQUENCE

September

AP REVIEW UNIT VI: Solids and Liquids
Kinetic Molecular Theory; phase diagrams for one-component systems; changes of state; structure of solids.
Liquids and solids form the kinetic-molecular viewpoint

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Phase diagrams of one-component systems
Changes of state, including critical points and triple points
Structure of solids; lattice energies

AP REVIEW UNIT VII: Solutions and Their Properties

Investigate the properties of solutions; factors affecting solubility; methods of expressing concentration; colligative properties.
Types of solutions and factors affecting solubility
Methods of expressing concentration (The use of normalities is not tested.)
Raoult's law and colligative properties (non-volatile solutes); osmosis
Non-ideal behavior (qualitative aspects)

Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

October

AP REVIEW UNIT I: Chemical Fundamentals

Describe the properties of matter; use significant figures correctly; perform basic scientific calculations and measurements.

AP REVIEW UNIT II: Atomic Structure and The Periodic Table

Account for the periodicity of the elements in terms of modern atomic theory; use atomic numbers, mass numbers and isotopes; understand electron energy levels, quantum numbers and atomic orbitals.
Evidence for the atomic theory
Atomic masses; determination by chemical and physical means
Atomic number and mass number; isotopes
Electron energy levels: atomic spectra, quantum numbers, atomic orbitals
Periodic relationships including, for example, atomic radii, ionization energies, electron affinities, oxidation states
Chemical reactivity and products of chemical reactions
Relationships in the periodic table: horizontal, vertical, and diagonal with examples from alkali metals, alkaline earth metals, halogens, and the first series of transition elements

November

AP REVIEW UNIT III: Chemical Bonding

Understand binding forces (ionic, covalent, metallic, network covalent, and Van der Waals) and their relationships to states, structure and properties of matter; polarity of bonds; electronegativities; molecular models; Lewis structures; Valence Bond theory (hybridization); resonance, sigma and pi bonds; VSEPR; Molecular Orbital theory.

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Binding forces
Types: ionic, covalent, metallic, hydrogen bonding, van der Waals (including London dispersion forces)
Relationships to states, structure, and properties of matter
Polarity of bonds, electronegativities
Molecular models
Lewis structures
Valence bond: hybridization of orbitals, resonance, sigma and pi bonds
VSEPR
Geometry of molecules and ions, structural isomerism of simple organic molecules and coordination complexes, dipole moments of molecules, relation of properties to structure

<u>December</u>

AP REVIEW UNIT IV: Chemical Compounds, Reactions and Stoichiometry

Calculate quantities of materials reacted or produced in chemical reactions; use mole concept to determine empirical formulas; be able to write formulas and name various inorganic compounds using IUPAC standards; be able to write and read chemical reactions.
Acid-base reactions; concepts of Arrhenius, Brönsted-Lowry, and Lewis; coordination complexes; amphoterism
Precipitation reactions
Oxidation-reduction reactions
Oxidation number
The role of the electron in oxidation-reduction

Ionic and molecular species present in chemical systems: net ionic equations
Balancing of equations including those for redox reactions
Mass and volume relations with emphasis on the mole concept, including empirical formulas and limiting reactants

Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

AP REVIEW AND NEW UNIT V: Thermochemistry

Relate the fundamental aspects of the energy changes that accompany chemical reactions.

<u>January</u>

AP REVIEW UNIT VI: Gases
Investigate the laws and models that describe the properties and behaviors of gases; Kinetic Molecular Theory
Laws of ideal gases
Equation of state for an ideal gas
Partial pressures
Kinetic-molecular theory

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Interpretation of ideal gas laws on the basis of this theory
Avogadro's hypothesis and the mole concept
Dependence of kinetic energy of molecules on temperature
Deviations from ideal gas laws
Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

AP NEW UNIT VIII: Kinetics

Measure, alter, and predict the rates of a chemical reaction.
Concept of rate of reaction
Use of differential rate laws to determine order of reaction and rate constant from experimental data
Effect of temperature change on rates
Energy of activation; the role of catalysts
The relationship between the rate-determining step and a mechanism

February

AP NEW UNIT IX: Chemical Equilibrium

Investigate the characteristics of chemical equilibrium; Le Chatelier's principle; equilibrium constant.
Concept of dynamic equilibrium, physical and chemical; Le Chatelier's principle; equilibrium constants
Quantitative treatment
Equilibrium constants for gaseous reactions: Kp, Kc
Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

AP NEW UNIT X: Thermodynamics

State functions; First Law; Second Law; Third Law; relationship of change in free energy to equilibrium constants.
State functions
First law: change in enthalpy; heat of formation; heat of reaction; Hess's law; heats of vaporization and fusion; calorimetry
Second law: entropy; free energy of formation; free energy of reaction; dependence of change in free energy on enthalpy and entropy changes
Relationship of change in free energy to equilibrium constants and electrode potentials
Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

March

AP NEW UNIT XI: Electrochemistry

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Apply the theoretical basis of oxidation-reduction reactions; electrolytic and galvanic cells; Faraday’s Law; standard half-cell potentials; Nernst equation; prediction of the direction of redox reactions. Electrolytic and galvanic cells; Faraday's laws; standard half-cell potentials; Nernst equation; prediction of the direction of redox reactions

AP NEW UNIT XII: Complex Ions and Coordination Compounds

Describe the chemical properties of some of the transition metals with an emphasis on the nomenclature of complex ions and compounds.

Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

<u>April</u>

AP NEW UNIT XIII: Nuclear Chemistry

Nuclear equations; half-lives; radioactivity; chemical applications.

AP NEW UNIT XIV: Acids and Bases

Acid-base reactions; concepts of Arrhenius, Bronsted-Lowry, and Lewis; amphoterism; pK; pH and pOH; common ion effect; buffers; hydrolysis.
Equilibrium constants for reactions in solution
Constants for acids and bases; pK; pH
Common ion effect; buffers; hydrolysis

Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

<u>May</u>

AP NEW UNIT XV: Solubility Product and Complex Ion Equilibrium

Calculate the solubility product of a salt given its solubility and vice versa; predict the relative solubilities from K_{sp} values; explain the effect of pH and a common ion on the solubility of a salt. Solubility product constants and their application to precipitation and the dissolution of slightly soluble compound

AP NEW UNIT XVI: Organic Chemistry

Become familiar with basic hydrocarbon chemistry, properties, and nomenclature.

<u>June</u>

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Students will work on remaining lab assignments while synthesizing the course material and preparing for course final.

Evaluations – Chapter Test, weekly quizzes,
Lab reports, homework

SUGGESTED LABS FOR USE DURING THE YEAR
SOLIDS & LIQUIDS: Molar Mass via Freezing Point Depression

Melting Point of an Organic Compound.
Qualitative Analysis: Anions.
Qualitative Analysis: Cations.
Determination of Electrochemical (Activity) Series.
ATOMIC THEORY PERIODICITY Analytical Gravimetric Determination
Determination of the Formula of a Compound.
Determination of the Percentage of Water in a Hydrate.
Determination of Mass and Mole Relationships in a Chemical Reaction.
Determination of Concentration by Oxidation-Reduction Titration.
Enthalpy of Neutralization.
Molar Volume of a Gas
Molar Mass Determination via Vapor Density
Determination of the Rate of a Chemical Reaction and its Order.
Determination of the Equilibrium Constant for a Chemical Reaction.
Investigation of Voltaic Cells-The Nernst Equation.
Synthesis of a Coordination Compound and its Chemical Analysis (if time permits).
Investigation of a Buffer System.
Determination of K_a of a Weak Acid.
Determination of pH.
Determination of K_{sp} of a Salt.
Synthesis, Purification, and Analysis of Aspirin.
Preparation of an Ester.

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Atlantic City School District

The wave of the future!

Academic Biology

9th & 10th Grades

Prepared by
Steve Nagiewicz, Barbara Hamill, George Quinn & Kevin Corcoran
Reviewed by
Supervisor of Science

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

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(Revised July 2017)

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II. OVERVIEW

Academic Biology is a one-year lab science course meeting six periods per week with at least one double lab period per week. It is an overview of the biological sciences with an emphasis on the process and application of biology. The student is introduced to the science of biology, the diversity of life, biochemistry, cellular structure and function, the basic needs of organisms, natural selection, ecology and interdependence, genetics, taxonomy, and application in biotechnology.

III. RATIONALE

Biology has become an important and essential part of student learning in the 21st century. As topics such as public health, environmental stability, and biotechnology are on the forefront of our daily lives, it is ever more important that students are prepared to understand and use the information available, as it changes constantly. Additionally, an understanding of the scientific process (scientific method, rational thinking skills) is essential for students to sort and evaluate incoming information.

IV. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

5.1 All students will develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.3 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.

5.4 All students will understand the interrelationship between science and technology and develop a conceptual understanding if the nature and process of technology.

5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.

5.6 All students will gain an understanding of the structure and behavior of matter.

5.7 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.

5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.9 All students will gain an understanding of the origin, evolution, and

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structure of the universe.

5.10 All students will develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.

V. STUDENT OUTCOMES

A. KNOWLEDGE (Information and Concepts)

The students will (verbally or in writing):

1. demonstrate a comprehensive knowledge of facts, terminology, concepts, generalizations, principles and scientific procedures that will help students confront and interpret occurrences in the everyday world.
[5.1.A.1.2.3.4,B.2; 5.3.A,B.1,C.1,D.1; 8.1.B.1.2.3; 8.2.A.5.8.9.10]**
2. summarize the characteristics that are common to all organisms
[5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
3. describe how technology has influenced the field of biology.
[5.1.A.1.2.3.4,B.1.2; 5.3.A,B.1,C.1,D.1; 8.1.B.1.2.3; 8.2.A.5.8.9.10]
4. describe the levels of organization in living systems from the simplest or atomic level to the most complex or organism level.
[5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
5. describe the properties of water that are essential to life.
[5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
6. explain the properties of carbon bonds and explain the structure of organic compounds.
[5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
7. explain the relationship among the classes of organic compounds and describe their properties.
[5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
8. describe the structure and function of the cell organelles.
[5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
9. compare the various ways in which substances enter and exit cells and describe the properties of the cell membrane and the fluid mosaic model.
[5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1]
10. describe the process of mitosis and the cell cycle.
[5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
11. define the role of energy and ATP in living things.
[5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
12. define photosynthesis, glycolysis and aerobic respiration.
[5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
13. describe the relationship between ecology and biology.
[5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 5.10.A.1; B.1.2; 8.2.A.1]
14. define population, community, ecosystem and biosphere.
[5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 5.10.A.1; B.1.2; 8.1.A.1]
15. evaluate the population dynamics of a predator/prey cycle.

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[5.3.A; 5.3.B.1; 5.3.C.1; 5.3.D.1]

16. explain the work of Darwin, relating various types of evidence to support his hypothesis and summarize the process of natural selection.
[5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.3.A.1; 8.1.C.1]
17. list various mechanisms for evolution including, genetic drift and sexual selection.
[5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.1.A.1; 8.2.C.1]
18. demonstrate knowledge of various classifications systems such as the 5-kingdom system and the three-domain system of classification and describe the identifying characteristics for each.
[5.2.B.1.2.3; 5.5.B.1; 8.1.A.1; 8.2.D.1]
19. describe the adaptations involved in the transition from an aquatic to terrestrial environment.
[5.5.B.1.2; C.1.2; 8.1.A.1; 8.2.D.1]
20. define taxonomy and describe how Linnaeus created modern taxonomy and how it changes as new evidence is found.
[5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 8.1.A.1]
21. understand the use of a dichotomous key in taxonomy.
[5.5.B.1.2;8.1.A.4; C.1]
22. identify the people who contributed to biogenesis and describe the various origin of life hypotheses including the evolution of metabolic pathways.
[5.1.A.1.3.4; B.2; 5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.2.A.1;]
23. define meiosis and explain its role in genetics and evolution.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
24. explain the work of Gregor Mendel and define his contribution to genetic theory.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1; 8.6.A.5.8.9.10]
25. apply the laws of segregation and independent assortment to explain the behavior of chromosomes during meiosis.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1;]
26. apply probability to genetic crosses using Punnett squares
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
27. describe how genes are related to chromosomes
[5.1.A.1.2;5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
28. compare different types of gene mutations and their effects.
[5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
29. explain the role of DNA as the carrier of genetic information.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
30. define the work of Watson, Crick and Franklin in determining the structure of DNA.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
31. trace the steps involved in DNA replication and protein synthesis.

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[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]

32. define bio-ethics and list the pros and cons of various current topics such as genetic engineering, stem cell research and cloning.
[5.2.B.1.2; 5.5.C.1.2.3; 5.10.A.1; B.1.2]

B. ATTITUDES
The student will:

1. suggest reasons for a nonscientist to be educated in science.
[5.2.A.1]
2. exhibit objectivity and sound decision-making in analyzing the bio-ethical issues confronting society in areas such as human genetics, medicine, reproduction, law.
[5.2.A.1; 8.1.B.1.2; 8.2.A.]
3. develop curiosity about the many unanswered questions in biology. [5.4.A.1; 8.1.B.1]
4. exhibit a fundamental respect for living things and the dependence of humans on other organisms.
[5.4.A.1; 5.4.B.1]
5. appreciate the significance and variety of possible careers in biology and applications of biology.
[5.2.A.1; 5.2.B.1.2.3; 8.2.A.1,2; 8.2.B.1,9.1, 9.2]
6. develop an appreciation of the role of technology in investigating, cataloging, comparing and altering living things.
[5.4.A.4; 5.4.B.1; 5.4.C.1.2]
7. develop a sense of wonder at the amazing complexity, unity and balance of life.
[5.2.A.1; 5.2.B.1.2.3; 8.2.A.1.2; 8.2.B.1]

C. SKILLS AND BEHAVIOR
The student will:

1. design an experiment with an experimental set-up and a control, and perform data analysis using varying techniques.
[5.1.A.1.3.4; 5.1.B.1.2; 5.1.C.1; 8.2.A.1]
2. demonstrate effective use of the compound light microscope and stereoscopic dissecting microscope.
[5.1.C.1; 5.1.B.1]
3. diagram accurate representation of size and shape of living things.
[5.3.C.1; 5.3.D.1;]
4. predict the outcome of an experiment.
[5.1.A.3.4; 5.1.B.2; 8.2.A.1]
5. classify organisms on the basis of similar morphology.
[5.3.B.1; 5.3.D.1]
6. compare biochemical sequences of several diverse species to infer evolutionary relationships.
[5.5.C.1.2]

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7. use a dichotomous key to identify an unknown species. [5.1.A.1; 5.3.B.1; 5.3.C.1]
8. follow safety rules and practices in all laboratory and field activities.
   [5.1.C.1]
9. use computer interfaced probes to collect and analyze data. [5.1.B.1; 8.2.C.1.2]
10. use technological tools for problem-solving, writing and research. [8.1.A.1.2.3.4]
11. locate, organize, summarize and evaluate information. [8.2.C.1.2]
12. be aware of the connection between educational activities and the world of work [9.1,9.2]

VI. STRATEGIES

Interactive lectures, including where appropriate:

- Use of flex cam
- Computer-TV interface
- Digital projector
- PowerPoint presentations
- Overhead transparencies
- Handouts
- Demonstrations

Problem-solving activities, such as:

- Model building
- Cooperative group work
- Bio-ethics debates

Computer programs to:

- Run simulations
- Generate and evaluate data
- Run review-CD applications

Laboratory investigations, including:

- Observation
- Experimental design
- Hypothesis testing
- Dissections

Internet resources, used to:

- Supplement textbook on Exploring Life web-site
- Search medical and other science related databases
- Perform literature searches
- Obtain current information
- Run on-line lab activities

Videos:

- PBS Scientific American Explorers
- Discovery channel

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NOVA
National Geographic

Independent projects

Make the appropriate accommodations for special needs and ELL students:

Additional time and other IEP stated accommodations

Audio text resources

Varied assessment

VII. EVALUATION

Assessment may include:

Exams
Quizzes
Lab reports
Lab notebook
Lab practicum
Homework
Classwork
Classroom Journal
Open Ended Questions'
Individual project
Group projects
Presentations

End of Course Biology Benchmark Assessment

STA test

VIII. REQUIRED RESOURCES

Student resources:

1. Textbook: Holt, Rinehart, and Winston. Modern Biology. Harcourt. 2002
2. Technology

    Laptop cart

    Word Processing and Data Base programs: Microsoft Office, etc.

    CD-ROM: Biology: Modern Biology

    Internet Resources: various

    Virtual Dissections
3. Supplemental material via Inclusion/LRC: Bernstein, Schachter, Winkler, Wolfe. Life Science: Concepts and Challenges. Globe.
4. Lab manual: open (several labs within the textbook)
5. Videos: various

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IX. SCOPE AND SEQUENCE

September

Life (Ch. 1)

Introduction
Scientific method, scientific process, logical thinking skills
Tools, techniques and skills for lab work
Microscope
Definition/characteristics of life
Themes in Biology
Biology and Society

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

October

Chemistry of Life (Ch. 2 & 3)

Atoms and molecules
Bonding
Ionic, covalent, hydrogen
Properties of water
Polarity, pH, Specific heat
Organic chemistry
Carbon bonds
Carbohydrates, Lipids, Nucleic Acids, Protein structure & function
Enzyme

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

November

Cells and Transport (Ch. 4 & 5)

History and Cell theory
Structure and function of organelles
Prokaryotes vs Eukaryotes
Fluid mosaic model of the cell membrane
Diffusion, passive and active transport

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

December

Photosynthesis and Respiration (Ch. 6 & 7)

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Energy and ATP
Photosynthesis
- Light reactions and Calvin cycle

Respiration
- Anaerobic vs. aerobic
- Glycolysis, Kreb's cycle, Electron transport
- Energy flow through ecosystem
- Material cycles

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

January

Cell Reproduction and Classic Genetics (Ch. 8 & 9)

Chromosomes
Mitosis
Meiosis
Probability
Mendel
- History
- Independent assortment and recombination, dominance
- co-dominance, incomplete dominance

Genetic Crosses, Punnett square

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

February/ March

Molecular Genetics (Ch. 10, 11, 12, & 13)

DNA, RNA and Protein synthesis
- History, Discovery
- DNA structure and function
- Replication, information storage, mutations, genes
- RNA structure and function
- Transcription, Translation, Protein synthesis

Gene expression
Human genetics
- Pedigrees, patterns of inheritance, genetic diseases

Biotechnology
- Genetic engineering, Cloning, Biotechnology techniques, Bioethics

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Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

March/April

History of Life on Earth (Ch. 14, 15, & 17)

- Origins of Life
- Geological and Ecological History of Life
- Evolution and natural selection
  - History, Darwin
  - Evidence
  - Fossils, geology
  - Principals of natural selection, speciation
- Human Evolution

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

April/May

Ecology (Ch 19, 20, 21, 22, & 23)

- Ecosystems, environment
- Climate change, mass extinctions
- Populations
- Communities, species interactions
- Succession
- Energy flow, biochemical cycles
- Biomes

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

May/June

Taxonomy (Ch. 18)

- Classification systems (Historical and current)
- 6 Kingdoms
- Animal Phyla

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam, Benchmark Assessment, Final Exam

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Honors Biology

9th & 10th Grades

Prepared by
Steve Nagiewicz, Barbara Hamill, George Quinn & Kevin Corcoran
Reviewed by
Supervisor of Science

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

(Revised July 2017)

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X. OVERVIEW

Honors Biology is a one-year lab science course meeting six periods per week with at least one double lab period per week. It is an overview of the biological sciences with an emphasis on the process and application of biology. The student is introduced to the science of biology, the diversity of life, biochemistry, cellular structure and function, the basic needs of organisms, ecology, natural selection, genetics, taxonomy, and applications in biotechnology. The honors level course will be more rigorous than Academic Biology in terms of content, depth of coverage and laboratory study. Entry into the Honors level course is dependent upon performance in previous science courses.

XI. RATIONALE

Biology has become an important and essential part of student learning in the 21st century. As topics such as public health, environmental stability and biotechnology are on the forefront of our daily lives, it is ever more important that students are prepared to understand and use the information available, as it changes constantly. Additionally, an understanding of the scientific process (scientific method, rational thinking skills) is essential for students to sort and evaluate incoming information.

XII. STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

- 5.1 All students will develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.
- 5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.
- 5.3 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.
- 5.4 All students will understand the interrelationship between science and technology and develop a conceptual understanding if the nature and process of technology.
- 5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.
- 5.6 All students will gain an understanding of the structure and behavior of matter.
- 5.7 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.
- 5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.
- 5.9 All students will gain an understanding of the origin, evolution, and structure of the universe.
- 5.10 All students will develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.

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XIII. STUDENT OUTCOMES

A. KNOWLEDGE (Information and Concepts)

The students will (verbally or in writing):

1. demonstrate a comprehensive knowledge of facts, terminology, concepts, generalizations, principles and scientific procedures that will help students confront and interpret occurrences in the everyday world. [5.1.A.1.2.3.4,B.2; 5.3.A,B.1,C.1,D.1; 8.1.B.1.2.3; 8.2.A.5.8.9.10]**
2. summarize the characteristics that are common to all organisms [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
3. describe how technology has influenced the field of biology. [5.1.A.1.2.3.4,B.1.2; 5.3.A,B.1,C.1,D.1; 8.1.B.1.2.3; 8.2.A.5.8.9.10]
4. describe the levels of organization in living systems from the simplest or atomic level to the most complex or organism level. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
5. describe the properties of water that are essential to life. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
6. explain the properties of carbon bonds and explain the structure of organic compounds. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
7. explain the relationship among the classes of organic compounds and describe their properties. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
8. describe the four levels of protein structure, and explain the significance of each structure. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.C.1]
9. explain how environmental factors such as temperature and pH effect the rates of enzymatic activity. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.4.C.1]
10. describe the structure and function of the cell organelles. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
11. compare the various ways in which substances enter and exit cells and describe the properties of the cell membrane and the fluid mosaic model. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1]
12. describe the process of mitosis and the cell cycle. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
13. define the role of energy and ATP in living things. [5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
14. define photosynthesis, glycolysis and aerobic respiration. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.2.A.1;]
15. explain the process of ATP formation in both mitochondria and chloroplasts. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.1.C.1]
16. trace the steps, and explain what happens in the following metabolic pathways: Light reactions of photosynthesis, Calvin-Benson cycle, Citric Acid cycle, Glycolsis, and Fermentation. [5.5.A.1.2.3; 5.6.A.1.7.8; 8.1.C.1]

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17. describe the relationship between ecology and biology, including the C, N, S, P, and H_2O biogeochemical cycles, and energy transfers.
[5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 5.10.A.1; B.1.2; 8.2.A.1]
18. define population, community, ecosystem and biosphere.
[5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 5.10.A.1; B.1.2; 8.1.A.1]
19. evaluate the population dynamics of a predator/prey cycle.
[5.3.A; 5.3.B.1; 5.3.C.1; 5.3.D.1]
20. explain the work of Darwin, relating various types of evidence to support his hypothesis and summarize the process of natural selection.
[5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.3.A.1; 8.1.C.1]
21. list various mechanisms for evolution including, genetic drift, bottleneck-founders effect, stabilizing selection, directional selection, disruptive selection, and sexual selection.
[5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.1.A.1; 8.2.C.1]
22. demonstrate knowledge of various classifications systems such as the 5-kingdom system and the three-domain system of classification and describe the identifying characteristics for each.
[5.2.B.1.2.3; 5.5.B.1; 8.1.A.1; 8.2.D.1]
23. describe the adaptations involved in the transition from an aquatic to terrestrial environment.
[5.5.B.1.2; C.1.2; 8.1.A.1; 8.2.D.1]
24. define taxonomy and describe how Linnaeus created modern taxonomy and how it changes as new evidence is found.
[5.2.A.1; B.1.2.3; 5.5.B.1.2; C.1.2.3; 8.1.A.1]
25. understand the use of a dichotomous key in taxonomy.
[5.5.B.1.2;8.1.A.4; C.1]
26. identify the people who contributed to biogenesis and describe the various origin of life hypotheses including RNA as the first self replicating molecule, the evolution of metabolic pathways, and the endosymbionic hypothesis.
[5.1.A.1.3.4; B.2; 5.2.A.1; B.1.2.3; 5.5.A.2.3; B.1.2; C.1.2; 8.2.A.1;]
27. define meiosis and explain its role in genetics and evolution.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
28. explain the work of Gregor Mendel and define his contribution to genetic theory.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1; 8.6.A.5.8.9.10]
29. apply the laws of segregation and independent assortment to explain the behavior of chromosomes during meiosis.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1;]
30. apply probability to genetic crosses using Punnett squares
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
31. describe how genes are related to chromosomes
[5.1.A.1.2;5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
32. compare different types of gene mutations and their effects.
[5.1.A.2,B.2; 5.4.B.1,C.2.3; 5.6.A.1.2.3.4.5.6.7.8,B.1.2; 8.2.A.1;]
33. explain the role of DNA as the carrier of genetic information.

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[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]

34. define the work of Watson, Crick and Franklin in determining the structure of DNA.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
35. trace the steps involved in DNA replication and protein synthesis.
[5.1.A.1.2; 5.2.A.1; 5.3.C.1,D.1; 8.1.A.1; 8.2.C.1;]
36. define bio-ethics and list the pros and cons of various current topics such as genetic engineering, stem cell research and cloning.
[5.2.B.1.2; 5.5.C.1.2.3; 5.10.A.1; B.1.2]

B. ATTITUDES
The student will:

1. suggest reasons for a nonscientist to be educated in science.
[5.2.A.1]
2. exhibit objectivity and sound decision-making in analyzing the bio-ethical issues confronting society in areas such as human genetics, medicine, reproduction, law.
[5.2.A.1; 8.1.B.1.2; 8.2.A.]
3. develop curiosity about the many unanswered questions in biology. [5.4.A.1; 8.1.B.1]
4. exhibit a fundamental respect for living things and the dependence of humans on other organisms.
[5.4.A.1; 5.4.B.1]
5. appreciate the significance and variety of possible careers in biology and applications of biology.
[5.2.A.1; 5.2.B.1.2.3; 8.2.A.1,2; 8.2.B.1;9.1,9.2]
6. develop an appreciation of the role of technology in investigating, cataloging, comparing and altering living things.
[5.4.A.4; 5.4.B.1; 5.4.C.1.2]
7. develop a sense of wonder at the amazing complexity, unity and balance of life.
[5.2.A.1; 5.2.B.1.2.3; 8.2.A.1.2; 8.2.B.1]

C. SKILLS AND BEHAVIOR
The student will:

1. design an experiment with an experimental set-up and a control, and perform data analysis using varying techniques.
[5.1.A.1.3.4; 5.1.B.1.2; 5.1.C.1; 8.2.A.1]
2. demonstrate effective use of the compound light microscope and stereoscopic dissecting microscope.
[5.1.C.1; 5.1.B.1]
3. diagram accurate representation of size and shape of living things.
[5.3.C.1; 5.3.D.1;]
4. predict the outcome of an experiment.
[5.1.A.3.4; 5.1.B.2; 8.2.A.1]
5. classify organisms on the basis of similar morphology.
[5.3.B.1; 5.3.D.1]

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6. compare biochemical sequences of several diverse species to infer evolutionary relationships. [5.5.C.1.2]
7. use a dichotomous key to identify an unknown species. [5.1.A.1; 5.3.B.1; 5.3.C.1]
8. follow safety rules and practices in all laboratory and field activities. [5.1.C.1]
9. use computer interfaced probes to collect and analyze data. [5.1.B.1; 8.2.C.1.2]
10. use technological tools for problem-solving, writing and research. [8.1.A.1.2.3.4]
11. locate, organize, summarize and evaluate information. [8.2.C.1.2]
12. be aware of the connection between educational activities and the world of work [9.1,9.2]

XIV. STRATEGIES

1. Interactive lectures, including where appropriate:
   - Use of flex cam
   - Computer-TV interface
   - Digital projector
   - PowerPoint presentations
   - Overhead transparencies
   - Handouts
   - Demonstrations
   - Textbook CD-Rom
2. Problem-solving activities, such as:
   - Model building
   - Cooperative group work
   - Bio-ethics debates
3. Computer programs to:
   - Run simulations
   - Generate and evaluate data
   - Run review-CD applications
4. Laboratory investigations, including:
   - Observation
   - Experimental design
   - Hypothesis testing
   - Dissections
5. Internet resources, used to:
   - Supplement textbook on Exploring Life web-site
   - Search medical and other science related databases

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Perform literature searches
Obtain current information
Run on-line lab activities

6. Videos

   PBS Scientific American Explorers
   Discovery channel
   NOVA
   National Geographic

7. Independent projects
8. Make the appropriate accommodations for special needs and ELL students:

   Additional time and other IEP stated accommodations

   Audio text resources

   Varied assessment

XV. EVALUATION

Assessment may include:

Exams
Quizzes
Lab reports
Lab notebook
Lab work
Homework
Classwork
Classroom Journal
Individual project
Group projects
Presentations
End of Course Biology Benchmark Assessment
STA test

XVI. REQUIRED RESOURCES

Student resources:

1. Textbook: Holt, Rinehart, and Winston. Modern Biology. Harcourt. 2002
2. Technology

   Laptop cart

   Word Processing and Data Base programs: Microsoft Office, etc.

   CD-ROM: Biology: Modern Biology

   Internet Resources: various

   Virtual Dissections

3. Lab manual: open (several labs within the textbook)
4. Videos: various

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XVII. SCOPE AND SEQUENCE

September

Life (Ch. 1)

Introduction
Scientific method, scientific process, logical thinking skills
Tools, techniques and skills for lab work
Microscope
Definition/characteristics of life
Themes in Biology
Biology and Society

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

October

Chemistry of Life (Ch. 2 & 3)

Atoms and molecules
Bonding
Ionic, covalent, hydrogen
Properties of water
Polarity, pH, Specific heat
Organic chemistry
Carbon bonds
Carbohydrates, Lipids, Nucleic acids Protein structure and function
Enzyme

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

November

Cells and Transport (Ch. 4 & 5)

History and Cell theory
Structure and function of organelles
Prokaryotes vs Eukaryotes
Fluid mosaic model of the cell membrane
Diffusion, passive and active transport

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

December

Photosynthesis and Respiration (Ch. 6 & 7)

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Energy and ATP
Photosynthesis
Light reactions and Calvin cycle
Respiration
Anaerobic vs. aerobic
Glycolysis, Kreb's cycle, Electron transport
Energy flow through ecosystem
Material cycles

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

January

Cell Reproduction and Classic Genetics (Ch. 8 & 9)
Chromosomes
Mitosis
Meiosis
Probability
Mendel
History
Independent assortment and recombination, dominance
co-dominance, incomplete dominance
Genetic Crosses, Punnett square

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

February/ March

Molecular Genetics (Ch. 10, 11, 12, & 13)
DNA, RNA and Protein synthesis
History, Discovery
DNA structure and function
Replication, information storage, mutations, genes
RNA structure and function
Transcription, Translation, Protein synthesis
Gene expression
Human genetics
Pedigrees, patterns of inheritance, genetic diseases

Biotechnology
Genetic engineering, cloning, Biotechnology techniques, Bioethics

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Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

March/April

History of Life on Earth (Ch. 14, 15, & 17)

- Origins of Life
- Geological and Ecological History of Life
- Evolution and natural selection
  - History, Darwin
  - Evidence
  - Fossils, geology
  - Principals of natural selection, speciation
- Human Evolution

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

April/May

Ecology (Ch 19, 20, 21, 22, & 23)

- Ecosystems, environment
- Climate change, mass extinctions
- Populations
- Communities, species interactions
- Succession
- Energy flow, biochemical cycles
- Biomes

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

May/June

- Taxonomy (Ch. 18)
  - Classification systems (Historical and current)
  - 6 Kingdoms
  - Animal Phyla
- Plants (Ch. 29)

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam, Benchmark Assessment, Final Exam

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AP Biology

11th & 12th Grades

Prepared by
Steve Nagiewicz, Barbara Hamill, George Quinn & Kevin Corcoran
Reviewed by
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Atlantic City Public Schools
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(Revised July 2017)

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XVIII. OVERVIEW

Advanced Placement Biology includes those topics regularly covered in a college biology course. This course differs significantly from the usual high school biology course with respect to the kind of textbook used, the range and depth of topics covered, the kind of laboratory work done by students, and the time and effort required of students. The textbook used for AP Biology is also used by college biology majors. The kinds of labs done by AP students equate to the kinds of labs experienced by college students.

The Advanced Placement Biology course is designed to be taken by students after successful completion of high school biology and chemistry. It aims to provide students with the conceptual framework, factual knowledge, and analytical skills necessary to deal critically with the rapidly changing science of biology.

This class meets six periods a week and includes one double period block of time for lab investigations.

XIX. RATIONALE

The Advanced Placement Biology course is designed to be the equivalent of a college introductory biology course usually taken by biology majors during their first year. After showing themselves to be qualified on the Advanced Placement Examination, some students, as college freshmen, are permitted to undertake upper-level courses in biology or register for courses for which biology is a prerequisite. Other students may have fulfilled a basic requirement for a laboratory science course and will be able to pursue their major.

XX. STUDENT OUTCOMES

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

5.1 All students will learn to identify systems of interacting components and understand how their interactions combine to produce the overall behavior of the system.

5.2 All students will develop problem-solving, decision-making, and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.3 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.4 All students will develop an understanding of technology as an application of scientific principles.

5.5 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.

5.6 All students will gain an understanding of the structure, characteristics, and basic needs of organisms.

5.7 All students will investigate the diversity of life.

5.8 All students will gain an understanding of the structure and behavior of matter.

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5.9 All students will gain an understanding of natural laws as they apply t motion, forces, and energy transformations.

5.10 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.11 All students will gain an understanding of the origin, evolution, and structure of the universe.

5.12 All students will develop an understanding of the environmental as a system of interdependent components affected by Human activity and natural phenomena.

A. KNOWLEDGE (Information and Concepts)
The students will (verbally or in writing):

1. develop in writing/discussion an understanding of key concepts of chemistry and their relationships to the study of living things as determined by the correct usage of formulas and equations as they relate to biological principles and processes that occur daily.
2. demonstrate in writing/discussion an understanding of the interaction of living and non-living components of the environment. [3.1,3.8,3.13; 5.4.5 5.4.8,5.9.11 - 5.9.1 5,5.9.1 9,5.9.22,5.9.23,5.1 0.6-5.10.8,5.10.11,5.10.12]
3. describe in writing/discussion an understanding of the biological system of classification.
[3.2,3.9,3.12, 4.10; 5.3.3-5.3.7,5.7.7]
4. describe in writing/discussion an understanding of the structure and function of cells, including the cell theory and cell organelles common to prokaryotic, eukaryotic, plant and animal cells. [3.2,3.12; 5.1.4,5.1.5, 5.1.8,5.2.9,5.22.12, 5.2.1 3,5.2.15,5.3.3-5.3.7,5.4.5-5.4.11,5.6.8,5.6.10-5.6.16]
5. summarize in writing/discussion an understanding of the structural organization and functioning of the vertebrate body.
[3.2.3.8,3.12; 5.1.4-5.1.8,5.3.3 5.3.7,5.4.5-5.4.8,5.4.10, 5.6.9-5.6.11,5.6.14]
6. summarize in writing/discussion an understanding of the structural organization and functioning of higher seed plants. [3.2,3.8,3.12,5.1.4-5.1.8,5.2.6, 5.2.10,5.2.12-5.2.13,5.3.3- 5.3.7,5.4.5-5.4.8,5.4.1 0,5.5.5-5.5.15]
7. explain in writing/discussion an understanding of heredity as determined by the correct application of genetic and statistical methods used for determining established hereditary patterns. [3.5.3.7,3.10,3.14,4.8,4.9,5.2.6, 5.2.1 0,5.3.3-5.3.7,5.4.5-5.4.11,5.5.5-5.5.8,5.5.10-5.5.15, 5.6.8-5.6.14,5.7.5-5.7.11]
8. describe in writing/discussion an understanding of Biological Theory of Evolution as determined by correctly interpreting fossil evidence, biochemical evidence, embryology evidence and other forms of indirect supportive evidence.
[3.2,3.3,3.8,3.11,4.6; 5.1.4,5.1.5,5.1.7,5.1.9,5.2.6-5.2.1 4,5.3.3, 5.3.7,5.4.5-5.4.11,5.5.5-5.5.15,5.6.8-5.6.17,5.7.5-5.7.13,5.11.8]
9. explain in writing/discussion an understanding of the processes of photosynthesis and respiration by successfully describing the chemical mechanisms involved with each.

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[3.2,3.3,3.7,3.12; 5.1.4,5.1.5,5.1.8,5.2.6-5.2.9,5.2.12-5.2.15,5.3.3,5.3.6,5.4.5-5.4.11,5.5.5-5.5.15,5.6.9-5.6.11,5.6.14, 5.6.17,5.7.8,5.7.9,5.7.12]

10. recognize and relate in discussion/writing past and current leaders of biology and their contributions.
    [3.2,3.5,5.3.3-5.3.7]

B. ATTITUDES
   The student will:
   1. demonstrate interest and involvement in biology by contributing extra projects to the classroom and through observations made of class discussions.
      [3,2.2,2.3, 2.5,3.1,3.6,3.15,4.1-4.5,4.7,5.1; 5.2.6-5.2.15]
   2. develop an appreciation for science and scientist that have affected our daily lives with precourse and postcourse surveys.
      [5.2.6,5.2.9- 5.2.11,5.2.13,5.2.15,5.4.5,5.4.6,5.4.8-5.4.10,5.5.7,5.5.8,5.5.10,5.5.12,5.5.15]
   3. describe in writing/discussion the ethical implications of using biological concepts and principles to alter human genetic inheritance. [5.1.2,5.11.4-5.1.7,5.1.9, 5.1.10,5.3.3-5.3.7,5.12.6,5.12.9]
   4. recognize in writing/discussion many of the various science and non-science professions that are related to the field of biology. [5.3.3-5.3.7]

C. SKILLS AND BEHAVIOR
   The student will:
   1. demonstrate proper use of biological tools and instruments such as the microscope, spectrophotometer, pH meter, dissecting implements, balance scales and other metric instruments of measurements during group and independent lab investigations.
      [5.2-5.7,5.9; 5.4.5-5.4.8,5.4.10,5.5.5- 5.5.1]
   2. . demonstrate in clearly stated and organized lab reports the correct process of solving problems using the scientific method.
      [5,1.11,2.2,2.4,2.6,2.10,3.6,3.8; 5.2.6-5.2.15, 5.4.9,5.4.10,5.5.5-5.5.15]
   3. demonstrate by observation proper aseptic technique when working with microorganism in laboratory investigations.
      [5.4,5.7,5.8,5.9,5.2.6 5.2.15,5.6.17]
   4. relate scientific method to local and global ranging biological problems.
      [5.2,5.8,5.1.4,5.3.6,5.3.7,5.4.8-5.4.10,5.10.6, 5.10.8,5.10.11,5.10.13,5.10.14,5.12.4-5.12.7,5.12.9,5.12.10]
   5. locate, organize, summarize and evaluate information. [8.2.C.1.2]
   6. be aware of the connection between educational activities and the world of work [9.1,9.2]

V. STRATEGIES

This course will not be just a place where facts are disseminated and tested. Students will not only learn the facts associated with biology but will also learn and use higher level thinking skills that are a requirement for successful living. Students will learn by applying critical thinking, reading, writing, listening, and problem

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solving skills to the biological concepts and principles presented in this course.

9. Interactive lectures, including where appropriate:
   - Use of flex cam
   - Computer-TV interface
   - Digital projector
   - PowerPoint presentations
   - Overhead transparencies
   - Handouts
   - Demonstrations
   - Textbook CD-Rom
10. Problem-solving activities, such as:
    - Model building
    - Cooperative group work
    - Bio-ethics debates
11. Computer programs to:
    - Run simulations
    - Generate and evaluate data
    - Run review-CD applications
12. Laboratory investigations, including:
    - Observation
    - Experimental design
    - Hypothesis testing
    - Dissections
13. Internet resources, used to:
    - Supplement textbook on Exploring Life web-site
    - Search medical and other science related databases
    - Perform literature searches
    - Obtain current information
    - Run on-line lab activities
14. Videos
    PBS Scientific American Explorers
    Discovery channel
    NOVA
    National Geographic
15. Independent projects
16. Make the appropriate accommodations for special needs and ELL students:
    - Additional time and other IEP stated accommodations
    - Audio text resources
    - Varied assessment

VI. EVALUATION

Assessment may include:

Exams

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Quizzes
Lab reports
Notebook
Performance Assessment
Homework
Class Participation

Students will also be expected to design and execute projects and/or original research.

VII. REQUIRED RESOURCES

Student resources:

1. Textbook: Campbell, Neil, Biology, 7th edition, Pearson – Benjamin Cummings, New York, 2004.
2. Lab manual: Holt, Rinehart, Winston, Holt Biosources Laboratory Program. Harcourt, 2002.
3. Technology

   Word Processing and Data Base programs: Microsoft Office

   Internet Resources: various

   Virtual Dissections

   Laptop cart

VIII. SCOPE AND SEQUENCE

September

Molecules and Cells

Biological chemist

Review of atoms, molecules, bonding, pH, and water.
Carbon, functional groups
Carbohydrates, lipids, proteins, nucleic acids
Chemical reactions, free-energy changes, equilibrium.
Enzymes: coenzymes, cofactors, rates of activity, regulation.

Cells

Prokaryotic and eukaryotic cells
Plant and animal cells.
Structure and function of cell membranes.
Structure and function of organelles, subcellular components of motility, cytoskeleton.
Cell cycle: mitosis and cytokinesis.

October

Energy transformations

ATP, energy transfer, coupled reactions, chemiosmosis.

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C-3 and C-4 photosynthesis
Glycolysis, fermentation, and aerobic respiration.

Heredity

Meiosis
Mendel's Laws, probability
Inheritance patterns: chromosomes, genes, alleles; interactions.
Human genetic defects

Unit Exam

November

Genetics

Molecular genetics

DNA: structure and replication

Eukaryotic chromosomal structure, nucleosome, and transposable elements
RNA: transcription, mRNA editing and translation
Regulation of gene expression
Mutations
Recombinant DNA, DNA cloning, hybridization and DNA sequencing
DNA and RNA viruses.

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

December

Evolution

Origin of life
Evidence for evolution
Natural selection
Hardy-Weinberg principle, factors influencing allelic frequencies
Speciation: isolating mechanisms, allopatry, sympatry, and adaptive radiation
Patterns of evolution, gradualism, punctuated equilibrium
Organisms and Populations

Principles of taxonomy and systematic, five kingdom system
Survey of Monera, Protista, and Fungi

January

Plants

Diversity; classification; phylogeny; adaptations to land, alterations of generations in moss, fern, pine, and flowering plants

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Structure and physiology of vascular plants
Seed formation; germination and growth in seed plants
Hormonal regulation of plant growth
Plant response to stimuli tropisms and periodicity

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

February/March

Animals

Diversity; classification; phylogeny; survey of acoelomate; pseudocoelomate; protostome and deuterostome phyla
Structure and function of tissues, organs and systems (emphasis on vertebrates), homeostasis and immune response
Gametogenesis, fertilization, embryogeny and development
Behavior

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

April

Ecology

Population dynamics; biotic potential and limiting factors
Ecosystems and community dynamics; energy flow, productivity, species interactions, and biomes
Biogeochemical cycles.

May/June

Research Project - TBA

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Academic Physics

11^{th} & 12^{th} Grades

Prepared by
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(Revised July 2017)

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I. OVERVIEW

Physics is a full year college preparatory course offered to students at the beginning of their high school science sequence. It is the intent of the course to develop in students a conceptual understanding of the scientific content, problem solving skills, critical thinking and inquiry skills, and an appreciation of the collaborative scientific process. Additionally, an understanding of the scientific process (scientific method, rational thinking skills) is essential for students to sort and evaluate incoming information. Topics in the course include mechanics, work and energy, electricity and magnetism, waves, and optics. Applications in Earth Science will be explored. The course provides many opportunities for students to increase their interest and appreciation of science. Activities will be realistic and meaningful to high school students, and have been selected to allow students to work individually and in groups. The course is designed to foster organization, responsibility, curiosity, and enjoyment of science.

II. RATIONALE

Physics has been developed to provide students with an introduction to the study of the physical laws of the universe which underlie the understanding of all other science disciplines. We believe that early acquisition of basic physics concepts will provide students with knowledge and skills necessary to gain a deeper understanding of chemistry and biology. The Physics curriculum incorporates the appropriate NJ Core Curriculum Content Standards and Cross Content Workplace Awareness Standards. Applications of earth science are included. This course will develop an understanding of the scientific process and the need to sort and evaluate collected information.

III. STUDENT OUTCOMES

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 8/2002).

5.1 All students will develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.3 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.

5.4 All students will understand the interrelationship between science

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and technology and develop a conceptual understanding if the nature and process of technology.

5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.

5.6 All students will gain an understanding of the structure and behavior of matter.

5.7 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.

5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.9 All students will gain an understanding of the origin, evolution, and structure of the universe.

A. KNOWLEDGE (Information and Concepts)

The students will (verbally or in writing):

1. understand, evaluate and practice safe procedures for conducting science investigations
[5.1.C.1, 5.3.A]
2. distinguish between vector and scalar quantities
[5.3.A]
3. recognize the variability of measured quantities. Distinguish between accuracy and precision
[5.1.B.1, 5.3.B.1]
4. define and distinguish between the following quantities: distance, displacement, speed, velocity and acceleration
[5.7]
5. describe the motion of objects in terms of displacement, velocity and acceleration
[5.7]
6. relate motion to the appropriate frame of reference (coordinate system), and in simple cases predict and compare motion in multiple frames of reference
[5.1.C, 5.7]
7. describe phenomena and perform calculations using the Law of Universal Gravitation
[5.1.A, 5.1.C.1, 5.7.A.3]
8. define and describe the relationship between impulse and momentum for a given object
[5.1.A, 5.1.C.1, 5.7.B.2]
9. describe various types of energy and energy transformations.
[5.7.A.5-6, 5.7.B.1-3]
10. describe the work-energy theorem and apply it to mechanical systems

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[5.7.B.1-3]

11. define and distinguish between thermal energy and temperature
[5.7.B.1, 5.8.B.1]
12. describe methods of heat transfer. Give examples of heat transfer into, out of and within the earth system
[5.7.B.1, 5.8.A.1, 5.8.B.1, 5.8.C.1]
13. define heat of fusion and heat of vaporization
[5.7.B.1]
14. describe Pascal's, Archimedes' and Bernoulli's principles as they relate to the behavior of fluids
15. describe waves as the transfer of energy, not matter
[5.7.B.1-4]
16. distinguish between longitudinal and transverse waves
[5.7.B.1]
17. explain how electromagnetic waves are generated and identify the components of the electromagnetic spectrum
[5.7.B.4]
18. describe the behavior of waves, including reflection, refraction and interference
[5.7.B.1]
19. describe light as a portion of the electromagnetic spectrum
[5.7.B.4]
20. explain how light is reflected, refracted or absorbed by matter and how colors appear as a result of this interaction. Describe the importance of this interaction in the energy balance of the earth
[5.7.B.1, 5.8.A.1, 5.8.B.1]
21. describe how convex and concave mirrors and lenses form images
[5.7.B.1]
22. distinguish between conductors and insulators and give examples of each
[5.7.B.1]
23. explain that charging is due to the separation of charges
[5.7.A.4]
24. define and describe electric potential and voltage. Relate to analogous potential energy concepts
[5.7.A.4, 5.7.A.6, 5.7.B.1]
25. describe electric current and the conditions necessary for its occurrence
[5.7.B.1]
26. define electrical resistance
[5.7.B.1]
27. describe magnetism and relate to the motion of charged particles
[5.7.A.7]

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28. demonstrate awareness and knowledge of careers in science through active participation in discussions, career days, field trips or other appropriate activities
    [5.1.A.4]
29. recognize in writing/discussion the current and past leaders of physics
    [5.2.B.1, 5.1.B.3, 9.2]
30. recognize how physics correlates with other disciplines as medicine, sports, electronics, astronomy and architecture
    [5.1.A.4, 5.2.B.2, 5.4.A.1, 5.9.D.1-2, 9.1]
31. distinguish between science and technology and cite examples of each
    [5.4.A.1, 9.2]

B. ATTITUDE
The students will:

1. acquire and demonstrate a positive attitude and appreciation for the study of physics
   [5.3]
2. develop a scientific curiosity and sense of involvement as a result of exposure to the history of physics
   [5.3]
3. discover that the physical laws studied are reflected or applied in many aspects of daily life. [5.3]
4. recognize that science is complex, understandable, fallible and ever changing
   [5.3]
5. recognize that technology offers risks and benefits, and that alternate solutions of varying merit often exist to solve problems
   [5.1.A.2, 5.4.B.1, 5.7.B.4]

C. SKILLS AND BEHAVIORS
The student will:

1. demonstrate organization by keeping a complete, detailed notebook and collections of news articles which will be checked or graded periodically
2. exhibit the proper and safe use of laboratory equipment and materials by successfully completing laboratory investigations
   [5.1.B.1, 5.1.C.1]
3. demonstrate a thorough knowledge of SI units through the use and manipulations of units in physics applications
   [5.3.A]
4. formulate models (Mathematical, conceptual, graphical) to examine and explain observed and/or measured physical quantities or

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phenomena
[5.1.A, 5.3.A, 5.3.D.1]

5. develop and implement meaningful investigations of physical phenomena based on experience and observations. Analyze and draw conclusions using computer applications based on experimental data
[5.1.A.1, 5.1.B.2, 5.3.A, 5.3.C.1, 8.1]
6. defend and critique scientific conclusions by citing evidence from data and using reasoning based on scientific principles
[5.1.A.1, 5.1.A.4]
7. present scientific investigations, analysis and conclusions in well organized laboratory reports
[5.1.A.4, 5.3.A, 5.3.B.1 5.3.C.1, 5.3.D.1]
8. work independently and in cooperative groups to successfully achieve common goals such as carrying out experiments, simulations or completing projects
[5.1.A.4]
9. add and subtract vectors using both mathematical and graphical methods
[5.3.A, 5.3.C.1]
10. perform motion calculations for constant acceleration conditions, including both one and two dimensional motion
[5.3.C.1]
11. develop and interpret graphs of motion: displacement vs. time, and velocity vs. time
[5.3.D.1]
12. describe and distinguish between Newton's Laws of Motion and use the knowledge to predict or explain observed phenomena
[5.3.A, 5.3.C.1, 5.7.A.1-2]
13. perform calculations using Newton's Laws of Motion
[5.3.A, 5.3.C.1, 5.7.A.1-2]
14. draw simple free body diagrams
[5.7.A.1-2]
15. determine the force that produces equilibrium when two other forces act on an object
[5.3.C.1]
16. analyze the forces and motion of objects on an inclined plane
[5.3.A, 5.3.C.1]
17. explain how the Law of Universal Gravitation applies to models of the origin of the universe, and current topics in astronomy
[5.7.A.3, 5.9.B.1, 5.9.C.1]
18. perform momentum calculations using the concept of a close system
[5.3.C.1]

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19. apply the principle of conservation of energy to perform calculations involving various forms and transformations of mechanical energy (potential and kinetic)
[5.3.C.1, 5.7.B.2]
20. design and assemble simple machines and determine its efficiency
21. perform calculations involving the transfer of heat and changes of state
[5.3.A, 5.3.C.1, 5.7.B.1]
22. describe energy sources and transfers to, from, and within the Earth system. Relate to weather and climate
[5.7.B.1]
23. investigate and use the theory of plate tectonics to explain the relationship among earthquakes, volcanoes, mid-ocean ridges, and deep sea trenches
[5.7.B.1-2]
24. relate wave speed, wavelength and frequency. Perform simple calculations for sound waves in air using the relationship
[5.3.A, 5.3.C.1, 5.7.B.1]
25. describe the Doppler effect and perform research to determine how it is important to theories about the origin of the universe
[5.9.D.1-2]
26. describe and calculate the forces exerted by charged particles using Coulomb's Law
[5.3.C.1, 5.7.A.4]
27. describe and diagram the electrical fields that exist around electrical charges
[5.7.B.4]
28. use the concept of electrical fields to explain and predict the behavior of objects in a field
[5.7.B.4, 5.7.B.6]
29. relate voltage, resistance, current and power in electrical circuits. Perform calculations for series and parallel circuits
[5.3.A, 5.3.C.1, 5.7.B.1]
30. draw and construct simple series and parallel circuits. Perform related laboratory predictions, measurements and analysis.
[5.3.C.1, 5.7.B.1]
31. describe and diagram magnetic fields
[5.7.B.7-8]
32. be aware of the connection between educational activities and the world of work [9.1, 9.2]

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IV. STRATEGIES

create and construct models
brainstorm ideas and formulate hypotheses
problem-solve through lab investigations
participate in group discussions
evaluate data
analyze procedures
apply student knowledge
make and test hypotheses
evaluate results and consequences
make the appropriate accommodations for special needs and ELL students:

additional time and other IEP stated accommodations
audio text resources
varied assessment

V. EVALUATION

Assessment may include:

observations
notebook evaluations
student projects and activities
written homework
lab reports
quizzes
tests
benchmark assessments
oral presentations
laboratory practice

VI. REQUIRED RESOURCES

1. Textbook: Conceptual Physics , Paul Hewitt, Addison Wesley 2002, 9th Edition
2. Ancillary and enrichment resources:
   PASCO Scientific, Physics Labs with Computers: Volume 1, PASCO Scientific, 1999.

   Internet sites devoted to Physics
   Various miscellaneous teacher resources

   Active Physics, Arthur Eisenkraft, Lab Manual, It's About Time Inc., 2000

   IEP Planning Code Book, Atlantic City Public Schools, Department of Special Services, 2002; (Inclusion Teacher Modeling IEP to student within course)

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Interactive Physics, MSC Software Corp, 2000

3. Technology
   - Laptop cart
   - Word Processing and Data Base programs: Microsoft Office
   - Webassign.net
   - Computer Assisted Labs

SCOPE AND SEQUENCE

September

Introduction
- Expectations
- Safety

Linear Motion
- Units
- Displacement vs. distance
- Vector vs. scalar quantities
- Frames of reference and coordinate systems
- Velocity, speed
- Average vs. instantaneous quantities
- Acceleration
- Free fall
- Graphing and interpreting graphs of motion (displacement vs. time and velocity vs. time)
- Accuracy and precision

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

October

Vectors
- Vector addition: graphical and numeric
- Pythagorean theorem; sine, cosine, tangent functions
- Vector components
- Resultants

Forces and Motion
- Force definition
- Newton's 1st Law
- Newton's 2nd Law

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Newton's 3rd Law
Action/Reaction pairs
Free Body diagrams
Frictional forces

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

November

Forces and Motion in Two Dimensions
Equilibrant force
Resultant forces and motion
Motion and forces on an inclined plane
Projectile motion
Circular motion
Universal Gravitation
Law of Universal Gravitation
Scientific notation
Gravitational fields - applications to astronomy, origin of stars and planets
Kepler's laws

Assessments – Benchmark Assessment, Chapter Test,
journal review, lab reports (informal)
Unit Exam

December

Momentum
Definition of momentum, impulse
Impulse-momentum theory
Definition and identification of "closed systems"
Conservation of momentum
Collisions
Energy and Work
Mechanical energy
Work - define and calculate
Work-energy theorem - energy transfer
Power
Conservation of energy

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Energy “losses” - friction, sound, etc

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

January

Thermal Energy

Temperature, heat
Kinetic-molecular theory
Thermometry and temperature scales
Heat transfer mechanisms
Specific heat
Heats of fusion and vaporization
Quantitative determinations of heat transfer
1st and 2nd Laws of Thermodynamics

Assessments – Benchmark Assessment, Chapter Test,
journal review, lab reports (informal)
Unit Exam

February

Fluids

Fluid properties
Pressure - Pascal’s principle
Buoyancy- Archimedes’ principle
Bernoulli’s principle

Waves

Energy Transfer
Longitudinal and transverse
Wave characteristics - wavelength, amplitude, frequency, speed, period
Interference - constructive and destructive
Reflection
Refraction
Diffraction

Sound

Description of sound
Speed in various media
Determinations of frequency, speed and wavelength
Decibel scale

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Pitch
Applications in music
Doppler shift

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

March

Electromagnetic spectrum

Properties of light
Wave-particle duality
Ray model vs. wave model
Luminous flux and illuminance
Light transmission, reflection and absorption
Color
Polarization
Law of reflection
Refraction
Mirrors
Lenses
Diffraction

Assessments – Benchmark Assessment, Chapter Test,
journal review, lab reports (informal)
Unit Exam

April

Static Electricity

Charged particles
Charging objects - separation of charged particles
Conductors and insulators
Electrical forces
Coulomb's law

Electrical Fields

Definition
Diagrams of fields around charged objects
Field strength
Potential energy
Capacitance

Assessments – Chapter Test, journal review, lab reports (informal)

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May/June

Current Electricity

Definition of current
Current in a circuit - necessary conditions Voltage and potential difference
Resistance Ohm’s law Circuit diagrams Series
circuits Parallel circuits
Power and energy
Applications

Magnetism

Properties of Magnets
Magnetic fields
Electromagnetism - fields around current carrying wires, coils
Forces in magnetic fields
Electromagnetic induction

Earth Science Applications

Weather and climate - energy transfer in the atmosphere
Astronomy

Assessments – Benchmark Assessment, Chapter Test, journal review, lab reports (informal)

Unit Exam Final Exam

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Atlantic City School District
The wave of the future!

AP Physics B

12th Grade

Prepared by
Steve Nagiewicz, Barbara Hamill, George Quinn & Kevin Corcoran
Reviewed by
Supervisor of Science

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

(Revised July 2017)

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OVERVIEW

AP Physics B is an algebra-based course that entails coverage of a wide-ranging spectrum of topics than the B-Level course. The text being utilized, John Wiley & Sons' *Physics*. Extended 7th edition [2007] by Cutnell & Johnson, is a standard text used in many 1st year University Physics Courses. This widespread usage ensures a fairly seamless transition for students aspiring to science careers. The course structure will emphasize formulation and justification of models used to describe physical behavior and processes. This regimen will help establish multiple connections between a myriad of phenomena and inquiry-based student investigations, thereby reinforcing relevancy and real-life context. The selection of problems will be challenging, reflecting extension of models or concepts developed in class, as well as preparation for the AP exam itself. The curriculum will also be infused with web-based activities, appropriate laboratory investigations, and a historical analysis of ideas and individuals - the latter to illuminate the enterprise and triumphs of physics as a human cultural achievement. Finally, the students will conduct a “hands on” research project at the end of the scholastic year, as a culminating activity.

RATIONALE

The course is developed for those students contemplating science careers. This course will develop an understanding of the scientific process and the need to sort and evaluate collected information.

STANDARDS

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book.

- 5.1 All students will develop problem-solving, decision-making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.
- 5.2 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.
- 5.3 All students will integrate mathematics as a tool for problem-solving in science, and as a means of expressing and/or modeling scientific theories.
- 5.4 All students will understand the interrelationship between science and technology and develop a conceptual understanding if the nature and process of technology.
- 5.5 All students will gain an understanding of the structure, characteristics, and basic needs of organisms and will investigate the diversity of life.
- 5.6 All students will gain an understanding of the structure and behavior of matter.
- 5.7 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.
- 5.8 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.
- 5.9 All students will gain an understanding of the origin, evolution, and structure of the universe.

STUDENT OUTCOMES

A. KNOWLEDGE (Information and Concepts)

The students will (verbally or in writing):

1. demonstrate a comprehensive knowledge of fundamental and more highly sophisticated concepts in linear and rotational Newtonian Dynamics, harmonic oscillation and resonance, and wave propagation.
   [5.6.A.8, 5.7.A.1-8, 5.7.B.1-4, 5.9.A, 5.9.C, 5.9.D.1]
2. show proficiency in using vector language, and methods from differential and integral calculus, to express, model, and manipulate various physical quantities or phenomena arising in diverse areas of physics, such as velocity, linear and angular momentum.
   [5.3.C.1, 8.1]
3. develop a knowledge of the history, evolution, interrelationships, and epistemology of key ideas in physics and an appreciation of the process as a cultural human achievement.

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[5.1.A.4, 5.2.B. 1-3, 5.4.A.1, 5.9.D.2]

B. ATTITUDE

The students will:

1. develop an appreciation for the discipline of physics and its relationship to the evaluation and potential resolution of pressing everyday economic, technical, and commercial problems. [8.2]
2. research and investigate possible careers in physics or physics-related engineering areas. [8.2, 9.1, 9.2]

C. SKILLS AND BEHAVIORS

The student will:

1. inculcate and reinforce good problem-solving, modeling, and approximation techniques essential in formulating viable descriptions of physical systems and making meaningful predictions.
   [5.1.A.1 & 3, 5.3.C.1, 5.9.D.2]
2. use spreadsheet and graphing software to analyze and report measurements and results from laboratory investigations.
   [2.3, 8.1, 8.2]]

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3. set up and perform experiments using computer interfaced sensors and associated resident software to calibrate instruments and collect data in various formats. [2.3, 8.1, 8.2]
4. demonstrate proper and safe use of laboratory equipment during experiments. [5.1.C.1]
5. work cooperatively in small groups to construct models, solve problems, and perform experiments. [5.4]
6. be aware of the connection between educational activities & the world of work [9.1, 9.2]

STRATEGIES

Interactive lectures
Problem solving activities
Inquiry-based group investigations
Use of computer interfaced data collection sensors
Independent projects
Real-time administration of AP exam questions under actual test conditions
Internet-based assignments and investigative activities
Biographical and historical reports and presentations

EVALUATION

Assessment may include:

Homework
Graded Assignments
Quizzes
Laboratory Investigations
Tests
Projects

REQUIRED RESOURCES

Student resources:

1. Textbook: Cutnell & Johnson, Physics [Extended 7th Edition]
   John Wiley & Sons, Inc., © 2007
2. Lab manual: PASCO Scientific, Physics Labs with Computers: Volumes 1 & 2[1st Edition] PASCO Scientific, © 1999
   Brueningsen & Krawiec, Exploring Physics and Math with the CBL System [1st Edition] Texas Instruments Incorporated, © 1994
3. Technology:
   Laptop Cart
   Word Processing and Data Base Program: Microsoft Office
   Webassign.net

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SCOPE AND SEQUENCE

September

Motion

Units and Measurements
Scalars and Vectors
1 Dimensional Kinematics
2 Dimensional / 3 Dimensional Kinematics
Projectiles

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

October

Dynamics

Uniform Circular Motion
Relative Motion
Force and Mass
Tension & Normal Forces
Uniform Circular Motion
Drag Force & Differential Equation for Terminal Velocity

Work, Energy, and Power

Work
Energy
Conservation of Energy
Work Done by Conservative and Nonconservative Forces
Work Done by Variable Forces
Kinetic and Potential Energies
Conservation of Mechanical Energy

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

November

Linear Momentum

Linear Momentum & Impulse
Law of the Conservation of Linear Momentum
1-Dimensional and 2-Dimensional Collisions

Rotation

Angular Displacement, Velocity and Acceleration
Relationship between Linear and Angular Variables
Rigid Bodies
Moment of Inertia Derivations and Torque
Rotational Variables and Newton's Second Law

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Angular Momentum
Conservation of Angular Momentum

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

December

Oscillations
- Simple Harmonic Oscillations (Kinematics & Dynamics)
- The Wave Equation
- Simple Pendulum
- Spring Mass Systems
- Physical Pendulum

Fluids
- Hydrostatics
- Fluid Pressure
- Pascal's Principle
- Archimedes Principle
- Fluid Dynamics
- Continuity Equation
- Bernoulli's Equation

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

January

Heat
- Heat & Temperature
- Thermal Expansion
- Heat Transfer
- Ideal Gas Laws and PV Diagrams
- Kinetic Theory and RMS Speed of Gas Molecules
- Laws of Thermodynamics
- Reversible Thermodynamic Processes
- Heat Engines and Carnot Cycle

Electric Charge & Electric Fields
- Electrostatics
- Coulomb's Law
- Electric Fields
- Motion of Charged Particles in an Electric Field
- Capacitors

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

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February

Electricity & Magnetism

- Electric Current, Resistance and EMF
- Electrical Resistivity, Power & Energy
- Resistors in Series and Parallel
- Kirchoff's Rules
- Magnetic Fields
- Magnetic Force on Electric Current
- Magnetic Force Due to a Current
- Magnetic Flux
- Electromagnetic Induction

Sound

- Traveling Waves
- Properties of Sound
- Standing Waves and Beat Frequencies
- The Doppler Effect

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

March

Optics – Reflection & Refraction

- Law of Reflection
- Snell's Law
- Total Internal Reflection – Fiber Optics
- Image Formation by Plane & Spherical Mirrors
- Image Formation by Lenses
- Image Formation by a Two-Lens System

Optics – Wave Phenomena

- Interference
- Superposition Principle
- Single & Double Slit Interference & Diffraction
- Diffraction Gratings
- Polarization
- Electromagnetic Spectrum

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

April

Light Theory

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Photoelectric Effect
Energy and Linear Momentum of a Photon
Energy Level Ionization
Emission Spectrum
Absorption Spectrum
Lasers
DeBroglie Wavelength
X-Ray Production
The Compton Effect

Nuclear Physics

Mass Number & Atomic Number
Nuclear Reactions
Alpha, Beta & Gamma Decay
Neutrino
Nuclear Forces
Nuclear Fission & Chain Reactions
$E=mc^2$ and Nuclear Reaction Applications

Assessments – Chapter Test, journal review, lab reports (informal)
Unit Exam

May

Review for AP B

Review for AP Test in May
Take Released AP Multiple Choice Tests
Do Released AP Free Response Questions
Take the Test

End of the Year

End of the Year Research Activity

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Atlantic City Public Schools

ANATOMY AND PHYSIOLOGY

Grade 10 - 12

Prepared by: Dr. John D. Edmunds

Recommended by: Science Supervisor

Atlantic City Public Schools
1300 Atlantic Avenue
Atlantic City, NJ 08401

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I. OVERVIEW

To provide students the opportunity to participate in an Anatomy and Physiology course that will study the microscopic and macroscopic structures and functions of the human body to the extent of a college level introductory course. The students will be able to demonstrate a cursory understanding of minor first aid practices. Additionally, this course will proffer periodic projects relating to a definitive understanding of the indicated anatomical system of study.

II. RATIONALE

Honors Anatomy and Physiology is an excellent option for any interested students who would like a more in-depth study of biology. The student must have successfully completed biology and will be required to have a recommendation from their biology teacher.

III. STUDENT OUTCOMES

A. KNOWLEDGE (Information and Concepts)

The student will:

1. The students will be able to dissect various vertebrates.
2. The students will understand the interrelationship between these vertebrates.
3. The students will be able to make comparisons to human structures through cat dissection.
4. The students will develop skills in dissection and other laboratory techniques while they compare body systems.
5. The students will be able to clinically apply content material in the form of case studies and computer simulation.
6. Demonstrate mastery of laboratory techniques.
7. Demonstrate mastery of critical thinking skills as applied to the analysis of physiological processes and problem solving.
8. Demonstrate particular care and attention to detail.
9. Demonstrate a willingness to collaborate and cooperate with classmates.
10. Demonstrate mastery of each selected topic by passing all topic assessments (may require

retests).
11. Complete all laboratory exercises including all written observations.
12. Pass all laboratory "practical" evaluations of lab technique.
13. Participate regularly in classroom discussion.
14. Demonstrate a willingness to collaborate and cooperate with classmates.

1.

B. ATTITUDES

1. develop an appreciation for the study of anatomy and physiology and how it relates to his/her everyday life. [8.1,8.2, 5.1, 5.2, 5.4.A, 5.10.B]
2. research and investigate possible careers involving anatomy and physiology. [8.1,8.2,8.6, 5.2, 5.4, 5.10]
3. recognize the impact of anatomy and physiology on every aspect of daily life. [8.1, 8.2, 5.1, 5.2, 5.4.A, 5.10.B]

C. SKILLS AND BEHAVIORS

1. demonstrate good problem-solving techniques. [8.1,8.2, 5.1, 5.4, 5.5]
2. write essays on specific topics in anatomy and physiology demonstrating comprehension of a given topic, i.e. the historical development of the subject. [8.1, 5.1, 5.2, 5.6]
3. demonstrate effective listening and note taking skills in lecture and discussion situations. [8.1, 5.1.A]
4. demonstrate proper and safe use of laboratory equipment and chemicals during experiments. [8.1, 5.1.C, 5.1.A]
5. use the scientific method in solving laboratory based problems and writing reports based on their solutions. [8.1, 5.1.A]
6. demonstrate in class discussion and in writing a comprehensive knowledge of anatomy and physiology. [8.1, 5.5.A, 5.5.B, 5.4]
7. work cooperatively in small groups to solve problems or perform experiments. [8.1, 5.1.A, 5.1.B]

8. use spreadsheet and graphing software to report results of laboratory investigations. [8.1,8.2, 5.4, 5.1)
9. design and produce presentations using Power Point presentation software. [8.1, 5.4]
10. utilize Internet search engines to locate anatomy and physiology related websites for research and review. [8.1,8.2]

IV. STRATEGIES

The following strategies/activities will be used:

1. Interactive lectures
2. Problem solving activities
3. Group work
4. Independent projects
5. Peer review

V. EVALUATION

Tests and quizzes
Lab reports
Laboratory practicum
Homework
Other class work
Notebook evaluation
Class participation

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Student projects
Computer driven spreadsheets and graphs
Oral and/or Power Point presentations
Students will also be expected to design and execute projects and/or original research.

VI. REQUIRED RESOURCES

Text book (TBA)
reference materials
audio-visual materials
computer software
internet resources
dissection lab (specimens, dissecting tools, microscopes)
alternative assessment activities

VII. SCOPE AND SEQUENCE

Topic Suggested time period follows (Pacing Guide)

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- Course Content 1st Quarter
9/5 – 11/22

1. Demonstrate an etymological understanding of rudimentary medical terminology and the historical association with science.
2. Explain the phylogeny and anthropology of *Homo sapiens*. Delineate a basic understanding of embryology.
3. Demonstrate an extensive understanding of the basic anatomical terminology, organismal organization, necessary life functions, and homeostasis.
4. Differentiate between organic and inorganic chemistry, with explanation of associated bonding mechanisms, and explain the structural composition of living matter.
5. Understand the anatomy of a generalized cell, and explain the physiology associated with membrane transport, cell division and protein synthesis.
6. Discuss and explain the generalized characters of epithelial tissue, connective tissue, muscle tissue, and nervous tissue.
7. Compare and contrast the classification of body membranes.
8. List and discuss the function and structure of the integumentary system, along with the significance of homeostatic imbalance of the system.

Course Content 2nd Quarter
11/27 – 1/11

1.Explain the function, classification and generalized structure of various osteological structures.
2.List the various bones associated with, and differentiate between, the appendicular and axial skeletons.
3.Discuss and explain the various muscle types, generalized activities of muscles, and the body movements
associated with muscle nomenclature.
4.List and discuss the gross anatomy and location of skeletal muscles.
5.Explain the classification, generalized structure and physiology of nervous tissue.
6.List, discuss, and differentiate between the structural functions of the central and peripheral nervous system.

4.

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- Course Content 3rd Quarter
  1/12 – 3/15

1. Discuss and explain the tissue specialization associated with the special senses, list their various anatomical structures, and illustrate all associated neuronal pathways.
2. Explain and illustrate the structure, physiology and location of the endocrine system and all of its components.
3. List and explain the composition, physiology and associated functions of the blood.
4. Describe and illustrate the components, functions and associated locations of the circulatory system.
5. Explain specific and nonspecific bodily defenses, with all associated structures and mechanisms.
6. List and describe the functional anatomy, physiology and disorders associated with the respiratory system.
7. Discuss and define the structure, functions, physiology and location of the variouis components of the digestive system.
8. Discuss the minimal nutritional requirements of human metabolism.

- Course Content 4th Quarter
  3/16 – 6/15

1. List and define the structure, location and physiology of the urinary system and its components.
2. Differentiate between male and female reproductive organs, their respective locations, cycles and physiology.
3. List and describe the physiology and physical mechanisms associated with fertilization and embryological development.
4. Demonstrate and adhere to all established safety guidelines while performing all laboratory dissection exercises.

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Atlantic City High School
Forensics Curriculum
Adopted September 2012
Revised 2016

Barbara Hamill, Steve Nagiewicz
Science Curriculum

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Hammonton High School District
Course Proficiencies and Pacing
FORENSIC SCIENCE

Unit Title	Essential question and Skills	Recommended Duration
Unit #1: Introduction to Forensic Science Supplementary material	**What is forensic science and, how has science become integrated into the practice of law? How do the different science disciplines used in Forensic Science help solve a crime in an investigation?** 1. Students will investigate various professions within the field of Forensic Science. 2. Students will explain the differences between the fictional /perceived and actual roles of a forensic scientist. 3. Explain the relationship of forensics and the law 4. Correlate the results of specific court cases to current forensics guidelines 5. Demonstrate courtroom proceedings 6. Research the work of various forensics pioneers 7. Describe the development of technology important to forensics 8. Students will develop an understanding of how evidence must be handled and described in order to be accepted in a court as valid evidence	2 weeks
Unit #2: Observation skills **Unit 1 Bertino**	**Why is eyewitness testimony not reliable in a court of law?** 1. Students will define Observations and what changes occur in the brain 2. Students will describe examples of factors influencing eyewitness accounts 3. Compare the reliability of eyewitness testimony to what actually happened	2 weeks
Unit #3: Crime Scene Investigation and Evidence Collection Bertino Chapter 2	**Why is proper evidence collection important when trying to solve a crime?** **How is evidence used to determine whether a crime has been committed?** 1 Explain the procedures used to process a crime scene. 2 Students will explain the proper way to classify and process evidence 3 Be able to secure a crime scene 4 Search a crime scene 5 Collect and properly package evidence and retain the “chain of evidence” 6 Draw and use a crime scene sketch	2 weeks
Unit #4: trace evidence Bertino Chapter 2,3,4	**How is trace evidence used to solve crimes** **What are different forms of trace evidence** 1. Understand the morphology of a hair follicle: cuticle, cortex, medulla, cortical fusi, ovoid bodies, root, follicle, pigment granules, follicular 2. Differentiate between human versus animal hair samples 3. Demonstrate the proper procedures in collecting and analyzing trace evidence 4. Compare hair samples using a collection of controls 5. Compare synthetic versus natural fibers 6. Test methods used for fiber identification	3 - 4 weeks
Unit #5 Impressions Bertino 16 & 17	**How are impressions a form of trace evidence that can be used to help solve crimes?** **How are different types of impressions used in criminal investigations?**	3 weeks

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	1. Students will distinguish between latent, patent and plastic impressions 2. Students will describe how to make foot, shoe, dental, and tire impressions. 3. Students will match tool marks with the instrument that produced them 4. Students will describe how tool mark evidence is collected preserved and documented	
Unit #6 Ballistics Bertino 18	**How does the study of ballistics in forensic science help in criminal investigations** 1. Students will discuss the differences between types of guns 2. Students will describe how shells and casing help solve crimes 3. Students will determine the position of the shooter based on bullet trajectory 4. Students will explain the role of ballistic recovery at a crime 5. Students understand how to distinguish entrance and exit wound 6. Students will evaluate and interoperate gunshot residue 7. Students will be compare and match striations left on bullets	3 weeks
Unit #7 Fingerprints Bertino Chapter 6	**How can fingerprints be used to identify individuals?** **How are fingerprints collected from a crime scene, or from items of evidence, used in forensic science to solve a crime?** 1. Discuss the history of fingerprinting 2. Describe the characteristics of fingerprinting 3. Explain what the basic types of fingerprints are 4. Discuss the latest's methods in lifting a fingerprint 5. Describe what AFIS is and how is it used to solve crime 6. Process latent prints on a variety of surfaces using different methods 7. Comparing fingerprints found at the crime scene with known samples	3 weeks
Unit #8: Document Examination Bertino chapter 10 Supplements	**How is document analysis used to help investigators solve crimes?** **What procedures are used by forensic scientists to process questioned documents?** . 1. Students will identify the characteristics of questioned documents that are most useful in forensic comparisons. 2. Students will explain how a sample of a handwriting evidence is compared with an exemplar using both qualitative and quantitative methods 3. Explain how to detect forgeries 4. Student will explain way to help prevent forgery 5. Students will explain the importance of evidence databases available to forensic scientists.	2 weeks
Unit #9: DNA Bertino Chapter 7	**How is DNA used to help solve crimes?** **Why can we use DNA to exonerate or convict suspects?** 1. Students will identify the characteristics of DNA that is most useful in forensic comparisons. 2. Students will be able to explain the 3. Students will demonstrate procedures used by the forensic scientist when processing DNA evidence. Students will explain the importance of DNA databases available to forensic scientists. 4. Explain the importance of STRs and various DNA markers to criminal investigations 5. Students understand the differences, application and limitations of Mt-DNA and Y-DNA 6. Describe the methods of DNA collection, amplification, and analysis 7. Explain the origin and working of the innocents project 8. Student can describe the process of DNA extraction and electrophoresis	3 weeks

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Unit #10: Serology Bertino 8 Supplements	**Describe the How is serology used to help solve crimes** **How are blood patterns used to help solve crimes** **How is urine, semen, vitreous humor and saliva analysis used to help solve crimes** 1. Define various components of blood, and the evidence each part contains 2. Explain various methods to test for blood at the crime scene 3. Describe the nature of blood type, and its relative importance as evidence 4. Describe different blood stain patterns based on source, direction, and angle of trajectory 5. Demonstrate how blood stain pattern analysis can aide in reconstructing a crime scene 6. Student will understand the stinging method and how it has become computerized 7. Explain the method of chemically isolating old, invisible blood stains 8. Determine the specific usefulness of each bodily fluid and what identifying substance can be extracted from each. 9. Determine the usefulness of Y-DNA and Mt-DNA in certain circumstances	2 weeks
Unit #11: Poisons and toxicology Bertino Unit 9 supplements	**What is the job of forensic toxicologists?** **How would identifying poisons and drugs help solve criminal cases?** 1. Describe the role of a forensic Toxicologist 2. Discuss the effects of drugs and poisons on the body 3. Describe analytical techniques for detection and identification of poisons and drugs 4. Compare the differences between poisons and drugs 5. Determine the effect of alcohol on the body and brain 6. Explain the science behind the breathalyzer test and why it reliable enough to hold up in court	2 weeks
Unit #12 Paints and fibers Bertino chapter 7 Saferstein Chapter 8 Supplements	**How is paint and fiber evidence collected and preserved? How would being able to identify chemical make up of paint and fiber aid in crime solving?** 1. Students will explain a monomers and polymers 2. Students will describe the different uses/types of paint 3. Students will distinguish between different types of fiber, including natural vs. man made 4. Students tell where paint evidence might be found 5. Students will research and describe various methods of paint and fiber analysis	
Unit #13 Anthropology Bertino Unit 14	**What is the job of forensic anthropologists?** **How do Forensic anthropologists use the remains of a Skelton to help solve criminal cases?** **What can be determined by analyzing skeletal remains?** 1. Describe the morphology of bones 2. Distinguish between male and female skeletal remains 3. Describe how bones contain a record of injuries and disease 4. Demonstrate how one can determined age, gender, race, height using skeletal remains 5. Explain how an investigator use the remains of a skeleton to identify a suspect or individual	2 weeks
Unit #14 Pathology Bertino Chapter 12	**What is the job of a forensic pathologist?** **How do Forensic pathologists use the remains of a body to help solve criminal cases?** 1. Discuss the definition of death 2. Distinguish between four manners of death	2 weeks

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	3. Explain how the development of rigor, algor and livor mortis can help determine time of death 4. Describe the stages of decomposition	
Unit # 15 Entomology Bertino Chapter 11	**What is the job of a forensic entomologist?** **How do entomologists employ insects to help determine times of death?** 1. Students will discover how the forensic entomology are involved in solving death cases 2. Students will determine how that forensic entomology can help determine the time of death 3. Students with gather and report information detailing the various types of arthropods that arrive at a body after death 4. Students will evaluate the effect of drugs and poisons in the body on the scavenging insects	Two weeks
Unit #16 Soils and botany Bertino Chapter 5 & 13	**What is the role of the forensics botanist? What role do plants and soils play in helping detective to reconstruct a crime scene?** 1. Students will describe different forms of biological evidence 2. Students will describe the various compositions of different soils 3. Students will Explain how the indigenous nature of plants and soils can aid in determining crime scene locations and discrepancies 4. Students will summarize the role of gymnosperms, angiosperms, seedless plants and fungi as evidence 5. Students will collect package and analyze soil and plant samples 6. Students will describe how differences in soil surface and plant habitation and growth can aid in discover a makeshift grave	
Unit #17 Glass Bertino Chapter 15	**How is glass evidence analyzed and used to help solve criminal cases?** 1. Students will tell the three major components of glass 2. Students will compare and contrast the properties of various classifications of glass 3. Students will calculate the density of glass 4. Student will understand the significance of the different fracture patterns 5. Student will determine the number of strike to the glass through understanding the patterns of multiple fractures multiple fractures 6. Student will describe how to determine direction of force on a piece of glass 7. define refractive index 8. Student will observe and describe the Becke line method for refractive index 9. Students will demonstrate the proper collection and packaging methods for glass evidence samples	Two weeks
Unit # 18 Fire, explosives and arsons Brown chapter 4 & 5	**What is the role of the Arson investigator? What role do plants and soils play in helping detective to reconstruct a crime scene?** 1. Student will define a combustion reaction 2. Students will explain fire ignition and maintenance conditions 3. Students explain why Arson is difficult to prove Student will use burn patterns to determine the origin and path of the fire 4. Students will describe what evidence to look for at a fire scene and how to process and collect evidence 5. Students will analyze accelerants 6. Students will identify characterizes of gases 7. Students will describe the different components of various types of explosives	

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NJCCCS:

Core Content standards used in Forensics

5.1.12 A1	Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations
5.1.12 A2	Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.
5.1.12 A3	Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.
5.1.12 B1	Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlation relationships, and anomalous data.
5.1.12 B2	Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.
5.1.12 B3	Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.
5.1.12 B4	Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.
5.1.12 C1	Reflect on and revise understandings as new evidence emerges.
5.1.12 C2	Use data representations and new models to revise predictions and explanations.
5.1.12 C3	Consider alternative theories to interpret and evaluate evidence-based arguments.
5.1.12 D1	Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.
5.1.12 D2	Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.
5.1.12 D3	Demonstrate how to use scientific tools, instruments, and knowledge of how to handle animals with respect for their safety and welfare.

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Atlantic City High School

Science Department Materials List

Forensics

HAMMONTON PUBLIC SCHOOLS
CURRICULUM PROJECT
Creating a Student-Centered Classroom

Content Area: Forensics
Grade Level: Grade 11-12
School: Atlantic City High School
COURSE SUMMARY **What is forensic science and, why has science become integrated into the practice of law? Who are the major contributors to the development of forensic science? What are the various specialty fields included within the broad realm of forensic science? How do real world roles and responsibilities of forensic professionals compare to fictitious versions portrayed on film? How evidence must evidence be handled in the laboratory and described in reports in order to be accepted in a court as valid evidence? Why is it necessary to have a team of personnel is needed to thoroughly investigate, evaluate, report and see a crime investigation through to a trail and conviction?**
2009 New Jersey Core Curriculum Standards including Cumulative Progress Indicator (CPI): **NJCCCS: NJCCCS:** 5.1.12 B1-4, C1-3, D1-3; 8.1.12 F1-2; 9.1.12 A1, A4; 9.1.12 F2, F6
Unit Enduring Understands: 1. Due to advances in science, forensic science has become integrated into the practice of law 2. Different professionals make up a crime scene unit 3. A team of personnel is needed to thoroughly investigate, evaluate, report and see a crime investigation through to a trail and conviction **4.** There are many differences between perceived and actual roles of forensic scientists
Key Knowledge and Skills students will acquire as a result of this unit: ***Students will be able to …*** 1. Students will **r**ecognize the major contributors to the development of Forensic Science including the advancements in tools, techniques, and crime lab services. 2. Students will identify various specialty professions within the field of Forensic Science.

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3. Students will explain the differences between the perceived and actual roles of a forensic scientist.

EVIDENCE OF LEARNING

Summative Assessment:

Projects
Chapter Test

Formative Assessments:
Quizzes

Written Assignments

Research Assignments

Student Self-Assessment and Reflection:
Lab conclusions
Essay response questions

Resources

Bettino, Anthony, J., Bertino, P. **Forensic Science Fundamentals and Investigations** 2nd Cengage Learning. 2016

Brown, R., Davenport, J., Forensic **Science Advanced Investigations**. Cengage Learning. 2012
DVD: ***CSI The First season***. *Paramount Pictures 2003*

Web resources:
a. Netflix, crime documentaries
b. school.cengage.com/forensicscience
d. projectinnocence.com
http://www.firearmsid.com/A_BulletID.htm
f. pbs.org
g. investigationdiscovery.com/investigation/forensics/forensics
h. fbi.gov
i. High School Teachers of Forensic Science (www.HSTOFS.org)
j. www.forensicdentistryonline.com/

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Atlantic City High School
Environmental Science

9^{th} - 12^{th} Grade
Curriculum Content

DRAFT

Steve Nagiewicz

Revised, August, 2018

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CONTENTS

Each of the following 'UNITS' are designed to be both standalone curriculum document and teacher lesson plan and have be constructed using NJ Science Core Curriculum Standards and Next Generation Science Standards.

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UNIT 1 Understanding Basic Science and the Environment	Number of Days: 9

Content Area: Environmental Science

Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, meteorology, botany, biology, chemistry and the social sciences.

Many of our objectives, lessons and essential questions will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world.

UNIT 1 Understanding Basic Science and the Environment will help student understand the differences of renewable and non-renewable natural resources, how humans use them and the impact on sustainability for the future of those resources. Students will understand how their personal use of resources makes a global impact or environmental 'footprint'. Students will learn about key concepts, persons and history developed the science of the environment. Students will use; case studies, scientific documents, essays, video documentaries, news stories, textbook assignments, lab experiment and lecture and group discussion and debate to develop their place in the environment.

Additionally students will learn the scientific method of solving issues in science and the environment as a process in decision-making, observation and interpretation. They will understand how their worldview and culture helps determine opinions and ethical standards in their lives and others. Students will understand how legal, economic and governmental issues and agencies affect environmental policies, decisions and how the government interacts with citizens and other countries to solve environmental issues. Students will use decision-making processes to solve critical environmental issues and be able to understand how graphs, data tables and open/closed systems are used to describe environmental systems.

Students will be able to integrate all of these concepts into developing informed in-class discussion/debates, opinion papers and presentations of the possible consequences of miss-use of natural or anthropogenic resources.

Grade Level: 9-12

21st Century Themes

	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

21st Century Skills

	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

Materials/Equipment needed:

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- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators
- Pearson Textbook and on-line/printed workbook
- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- maps
- ACHS Media Center – Gale Databases, library collections
- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

- **DVD:** NGS Human Footprint, The Lorax, Rachel Carson-Silent Spring, Earth from Space (pbs.org)
- **NBC Learn** news stories videos, Easter Island, Carbon Footprints**…**and more.
- **Eco-Footprint web sites:**
  National Geographic
  http://www.nationalgeographic.com/xpeditions/lessons/14/g68/HumanFootprint.pdf
  http://education.nationalgeographic.com/education/media/human-footprint-interactive/?ar_a=1
  Nature.org
  http://www.nature.org/greenliving/carboncalculator/?matchtype=b&creative=33211791470&device=c&network=g&src=sea.AWG.PR0.CP131.AD159.KW11243.MT1.BU132&gclid=CjwKEAjwre6dBRC94d-Gma7g3wcSJACNatZeyr6zvFaAbW6KaoE5nSL6bnbElPV-1CUtdxadM21lyRoC1WHw_wcB
  My Footprint http://www.myfootprint.org/
  World of 7 Billion http://www.worldof7billion.org/images/uploads/Watch_Your_Step.pdf
  US EPA http://www.epa.gov/airnow/workshop_teachers/calculating_carbon_footprint.pdf
- **Essays:**
  Rachel Carson (*Silent Spring*)is considered the founder of modern Environmental Science.
  https://docs.google.com/viewer?url=http%3A%2F%2Fwww.science.smith.edu%2F~jcardell%2FCourses%2F
  EGR100%2Fprotect%2Freading%2FSilentSpring.pdf
  Garrett Hardin – Tragedy of the Commons.
  http://www.garretthardinsociety.org/articles/art_tragedy_of_the_commons.html and ancillary resources: https://www.youtube.com/watch?v=B0vmP7HoFI4
  Ancillary Web-based Resources for Tragedy of the Commons
  https://www.youtube.com/watch?v=MLirNeu-A8I
  https://www.khanacademy.org/economics-finance-domain/microeconomics/consumer producer-surplus/externalities-topic/v/tragedy-of-the-commons
- **Chapter PowerPoint's**
- **Student Workbook Assignments – Chapters 1 & 2**
- **Chapter and Lesson Assessments**
- **Chapter Quizzes**
- **LABS**
  Computing and graphing Ecological Footprints
  Using the Scientific Method
  Using Maps

Optional DVD/Web-based suggestions: Environmental Issues and Human Impact (www.cambridgeeducational.com) Environmental Ethics (www.videoproject.com)

Web-based video about the implications for worldwide for environmental sustainability.

Video: http://www.youtube.com/watch?v=xkrJH9tt4qQ

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Website: http://csis.org/program/seven-revolutions

Cross-Curricular References/Projects:

HISTORY

- United States Environmental Protection Agency Polices and laws http://www2.epa.gov/laws-regulations
- NOVA/PBS Timeline – Modern Environmental policy http://www.pbs.org/wgbh/americanexperience/features/timeline/earthdays/
- National Resources Defense Council http://www.nrdc.org/reference/laws.asp
- Environmental History http://www.environmentalhistory.org/

MATH

- Reading and understanding graphs and charts. http://www.tv411.org/reading/understanding-what-you-read/reading-charts-and-graphs
- https://www.khanacademy.org/
- Bar, Pie and line graph PowerPoint. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CCYQFjAB&url=http%3A%2F%2Fwww1.whsd.net%2Fcourses%2FJ0077%2FUnit_01_-_Statistics_and_Data%2FBar%2520Circle%2520and%2520Line%2520Graph%2520PowerPoint.ppt&ei=sSO8U_SCCLXMsQTY24CwBQ&usg=AFQjCNGqqRym3Rz702lzuAFKL9k3koDamg&sig2=6jGCAevqIAz3024CVeUSeQ&bvm=bv.70138588,d.ZGU

Stage 1: Desired Results (Learning Targets)

Standards (Include cross-curricular)

Science - NJ 2009 Core Curriculum Content Standards (NJCCCS)

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. (Grades: 9,10,11,12)

5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. (Grades: 9,10,11,12)

5.1.A Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. (Grades: 9,10,11,12)

5.1.A.5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. (Grades: 9,10,11,12)

5.1.A Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. (Grades: 9,10,11,12)

5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)

5.1.A Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. (Grades: 9,10,11,12)

5.1.A.5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. (Grades: 9,10,11,12)

5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. (Grades: 9,10,11,12)

5.1.B Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. (Grades: 9,10,11,12)

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5.1.B.5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. (Grades: 9,10,11,12)
5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)
5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)
5.1.C Reflect on Scientific Knowledge: Scientific knowledge builds on itself over time. (Grades: 9,10,11,12)
5.1.C Refinement of understandings, explanations, and models occurs as new evidence is incorporated. (Grades: 9,10,11,12)
5.1.C.5.1.12.C.1 Reflect on and revise understandings as new evidence emerges. (Grades: 9,10,11,12)
5.1.C Data and refined models are used to revise predictions and explanations. (Grades: 9,10,11,12)
5.1.C.5.1.12.C.2 Use data representations and new models to revise predictions and explanations. (Grades: 9,10,11,12)
5.1.C Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges. (Grades: 9,10,11,12)
5.1.C.5.1.12.C.3 Consider alternative theories to interpret and evaluate evidence-based arguments. (Grades: 9,10,11,12)
5.1.D Participate Productively in Science: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms. (Grades: 9,10,11,12)
5.1.D Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work. (Grades: 9,10,11,12)
5.1.D.5.1.12.D.1 Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. (Grades: 9,10,11,12)
5.1.D Science involves using language, both oral and written, as a tool for making thinking public. (Grades: 9,10,11,12)
5.1.D.5.1.12.D.2 Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. (Grades: 9,10,11,12)
5.1.D Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically. (Grades: 9,10,11,12)
5.1.D.5.1.12.D.3 Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. (Grades: 9,10,11,12)

Next Generation Science Standards NGSS
HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-1. **Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

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HS-ESS3-2. **Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*** [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. **Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.** [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [*Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.*]

HS-ESS3-4. **Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geo-engineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-5. **Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.*]

HS-ESS3-6. **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

HS-ETS1 Engineering Design

Students who demonstrate understanding can:

HS-ETS1-1. **Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.**

HS-ETS1-2. **Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.**

HS-ETS1-3. **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**

HS-ETS1-4. **Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**

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Writing techniques, essay and opinion papers, and grammar subjects. MLA/APA Citations
Reading Comprehension Skills
History/Social Studies

Enduring Understandings: (What Students will know)	**Essential Questions**
1. That the world today may or may not better place than the world of the past because of human impacts. 2. Humans have to learn to maintain sustainability in for a better future. 3. Knowing cause and effect will help us make better informed decisions. 4. Understand how to evaluate evidence that is reasonable and valid. 5. Reasonable evidence will help us to solve problems and make decisions. 6. Visual data, math and graphs help us to understand impacts and causes and consequences. 7. Certain environmental issues are problems are of concern for historians, geographers, civic leaders, economists and studying evidence from the past help us prevent future problems and make informed decisions that will better affect our future.	1. How do you use a decision-making model to make a decision about an environmental issue? 2. What values are important in making decisions about the environment? 3. What is an Ecological Footprint and why is it an important calculation to studying effects on the environment? 4. What was the lesson learned from the Tragedy of the Commons? How does this apply to the People of Easter Island? Does it? 5. What is Economics and how does it affect the environment? 6. Using several key international environmental protocols relate how they could affect the environment? Governing? Economics? 7. How has U.S. Environmental Policy affected industry and the common citizen? 8. Explain why Earth Day was an important event? 9. Explain why we need natural resources? 10. How can you solve a scientific problem using Scientific Method?

Stage 2: Evidence of Learning

Performance Task 1: Essay on Tragedy of the Commons Page 11. Scoring Rubric Included

Performance Task 2: Research, Imagine, and Illustrate an annotated poster of what your Future might look like in 30 years using information learned from this lesson like ecological footprint, natural resources and concepts Tragedy of the Commons, The Lorax and our personal world-view, cultural differences and ethics. Using the included scoring rubric. Scoring Rubric Included

Supplemental Performance tasks:
Calculate/graph Ecological Footprints. Pages 9-10
DVD/Media Opinion Papers
Chapter 1 Quiz
Chapter 2 Quiz

Other evidence of learning:

Chapter quiz

Vocabulary – Student-centered worksheet/puzzles.

Central Case Studies – Student Discussion/Debate on 'Big-Question.'

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Chapter Worksheets:
Key concepts, Flow Charts, Open-ended questions,

Student Participation:
Student originated questions and debate about lecture topics, chapter issues and current events from news.

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Stage 3: Learning Plan	
Objectives	
The Students will know: • Scientific Method. • Decision-making models. • Build/analyze data tables & graphs. • Science Concept: Ecological Footprint/CO_2 • Science Concept: Non-renewable and Renewable resources. • Anthropogenic Effect on environment. • Basic Economics. • National/International Environmental policy. • Public Advocacy.	**The Students will be able to (TSWBAT):** • Identify the steps involved with solving issues, questions and problems using organized process of evidence-gathering, inquiry, observation and analysis. • Explain how humans affect their environment by their use of natural resources. • Understand and explain how economics and world-view, culture and ethics impact society and the environment. • Interpret basic graphs and tables. • Increase their reading comprehension of scientific papers and news stories and develop personal opinion based upon evidence, inquiry and observations. • Understand how government at every level works with key issues about the environment. • Identify the individual's role in making environmental policy.

Learning Activities/Instructional Strategies	
Lesson	**Timeframe**
UNIT 1 Understanding Basic Science and the Environment – Lesson 1 Overview (Chapter 1) **Key Terms:** Environmental science, environment, natural resource, non-renewable natural resource, renewable natural resource, sustainable, fossil fuels, ecological footprint. • Introduce the definition of Environmental Science. Discussion about the current issues about the environment, locally, national and world-wide. • Discussion on Essential Questions/Objectives • Lecture-PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Central Case/Discussion Ozone Hole in the Atmosphere. Page 3 Textbook. • How human population has changed use of natural resources.	**2 days**
UNIT 1 Ecological Footprints – Lesson 2 Human Footprint DVD – Students complete Questions associated with documentary. • Teacher-Lecture on what is and how CO_2 is produced and accumulated in atmosphere or oceans. http://www.epa.gov/climatechange/ghgemissions/gases/co2.html http://destinationcarbonneutral.co.nz/what-are-carbon-dioxide-emissions-co2-and-why-are-they-harmful/ • Calculating Ecological footprints. Textbook pages 9-10 (Internet or alternate sources) Student Lab-calculate, build data table and graph student personal (or provided examples) carbon footprint. Interactive web-based calculations. National Geographic	**3 days**

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http://www.nationalgeographic.com/xpeditions/lessons/14/g68/HumanFootprint.pdf http://education.nationalgeographic.com/education/media/human-footprint-interactive/?ar_a=1 Nature.org http://www.nature.org/greenliving/carboncalculator/?matchtype=b&creative=33211791470&device=c&network=g&src=sea.AWG.PR0.CP131.AD159.KW11243.MT1.BU132&gclid=CjwKEAjwre6dBRC94d-Gma7g3wcSJACNatZeyr6zvFaAbW6KaoE5nSL6bnbElPV-1CUtdxadM21lyRoC1WHw_wcB My Footprint http://www.myfootprint.org/ World of 7 Billion http://www.worldof7billion.org/images/uploads/Watch_Your_Step.pdf US EPA http://www.epa.gov/airnow/workshop_teachers/calculating_carbon_footprint.pdf	
UNIT 1 Tragedy of the Commons. "Learning from the Past" • Lecture on Tragedy of the commons, including Garrett Hardin's Essay. Student two (2) page essay about how he discusses how resources that are open to unregulated exploitation will eventually is depleted. In your paper discuss how this might affect society and our environment in general. **Think/write and discuss** in the context of Tragedy of the Commons what are the consequences of over-grazing, deforestation, ocean pollution, salinization/erosion of soils, global climate change, over-population, mass consumption of natural resources. • Assess student's skills and mastery of concepts and issues through use of open-ended questions and teacher-student debate and discussion. Assess written essay and presentation of student thoughts, comprehension of issue and writing skill. Links: http://www.garretthardinsociety.org/articles/art_tragedy_of_the_commons.html Below are two YouTube Video links that can help you understand what the Tragedy of Commons means in somewhat easier terms. https://www.youtube.com/watch?v=B0vmP7HoFI4 https://www.youtube.com/watch?v=MLirNeu-A8I https://www.khanacademy.org/economics-finance-domain/microeconomics/consumer-producer-surplus/externalities-topic/v/tragedy-of-the-commons	**3 days**
UNIT 1 Scientific Method	**2 days**

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Key Terms: Hypothesis, prediction, independent variable, dependent variable, controlled study, data, peer review, theory, ethics, environmental ethics. • Lecture on the steps required to describe and understand and test the process of science. • Quick Lab (page 22) or Alternate on how to develop a hypothesis and follow the required steps of the Scientific Method. • Student worksheet. • Assess student's skills and mastery of concepts and issues through use of open-ended questions, in-class discussions and hands-on assignments. • Handouts, web-based information http://www.sciencebuddies.org/science-fair-projects/project_scientific_method.shtml http://www.sciencemadesimple.com/scientific_method.html http://quizlet.com/2760708/pearson-success-biology-exploring-life-flash-cards/ Video: http://education-portal.com/academy/lesson/scientific-evaluation-of-environmental-problems-process-and-steps.html#lesson http://education-portal.com/academy/lesson/the-scientific-method-applied-to-environmental-problems-definition-steps-and-applications.html#transcript	
UNIT 1 Ethics-Environmental Justice • Discussion about student's world-view, cultures and ethics and how they might apply to the environment and where does the student see themselves in 30 years. • Links: http://www.epa.gov/environmentaljustice/ http://www.theguardian.com/sustainable-business/2014/jul/08/bob-massie-social-justice-environment-us-new-economy-coalition	**1 day**
UNIT 1 Rachel Carson – "*Silent Spring*" • Rachel Carson is considered the founder of modern Environmental Science. Please read this link to her book *Silent Spring* https://docs.google.com/viewer?url=http%3A%2F%2Fwww.science.smith.edu%2F~jcardell%2FCourses%2FEGR100%2Fprotect%2Freading%2FSilentSpring.pdf Please write a one page response of how you feel about what she wrote and thought? Why did this have such a huge impact on the world? Some quick Internet research can help you complete this assignment. (teacher may shorten the reading and select various sections of the reading or assign as homework or in-class reading or use DVD Rachel Carson) • Assess student's skills and mastery of concepts and issues through use of open-ended questions and written response to reading comprehension.	**2 days**
UNIT 1 Economics and the Environment. Chapter 2 **Key Terms:** Economics, supply & demand, cost-benefit analysis, ecological economics, environmental economics, non-market value, market failure, eco-labeling. • Teacher Lecture or PowerPoint on Economics and its impact on the environment. • Vocabulary and open-ended questions – student worksheet • Quick Lab (page 37 textbook) or teacher supplied lab on cost-benefit analysis	**2 days**

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• Student Activity: develop a flow chart of how natural resources are used and converted into local, state, national economies. • DVD the Lorax. Questions relating to use of natural resources, economics and lesson or moral of the movie concepts. • Assess students skills and mastery of concepts and issues through use of open-ended questions and student-teacher debate/discussion on moral of story. • Links: http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/homepage http://ec.europa.eu/environment/enveco/	
UNIT 1 Environmental Policy – Lesson Chapter 2, lesson 3 **Key Terms:** Command and control approach, subsidy, green tax, cap and trade, lobbying. • Teacher Lecture/PowerPoint on what is environmental policy, who administers it on all levels of government • History of United States environmental Policy and discussion of how policy and various enacted 'Acts' have impacted the country and environment. • International Organizations and Protocols for environmental Protection and why or why not they are successful. • Student worksheet • Links: http://www.sciencedaily.com/news/earth_climate/environmental_policy/ http://www.epa.gov/compliance/nepa/	**1 day**
UNIT 1 Chapters Assessments • Chapter Quiz • Assess students skills and mastery of concepts and issues through use of open-ended questions, multiple choice and essay.	**1 day**

Individual Accommodations
• Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team. • Modified worksheets, quizzes and other assignments as required. • Provide enrichment assignments for early finishers. • Provide limited Extra Credit assignments. • Allow for additional time for different learning styles. • Differentiate instruction for varied learning styles. • Include technology into the classroom. • Allow for group interaction. • Encourage use 'flipped' classroom instruction by students. • Develop make-up assignments, quizzes and test as required. • ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature___________________________________
Date_____________________

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UNIT 2 Structure of the Earth	**Number of Days: 9**

Content Area: Environmental Science

Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them. Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, meteorology, botany, biology, chemistry and the social sciences.

Many of our <u>objectives, lessons and essential questions</u> will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world.

<u>UNIT 2 Structure of the Earth</u> will help student understand the how the Earth is divided into different spheres or layers that describe their make-up as opposed to their location, although both are important. This is the physical Geology that is part of the interdisciplinary part of Environmental Science. Each of these spheres interacts with others to provide for our environment and without them working together life on earth would be non-existent or much different than it currently is. These five (5) basic 'sphere's' have many different levels and compositions themselves and each has specific purposes for life on the planet.

Additionally students will learn what each is, how it functions and inter-relates to other layers/spheres. Students will be able to understand feedback loops which are either negative or positive systems are used to describe environmental processes. Students will be able to integrate all of these concepts into developing informed in-class discussion/debates, opinion papers and presentations of the possible consequences of miss-use of natural or anthropogenic resources.

Grade Level: 9-12

<u>21st Century Themes</u>

	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

<u>21st Century Skills</u>

	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

Materials/Equipment needed:

- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators
- Pearson Textbook and on-line/printed workbook

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- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- maps
- ACHS Media Center – Gale Databases, library collections
- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

- **DVD: Suggested DVD's (select one or parts from one as time appropriate…)**
  Earth from Space (pbs.org)
  Discovery School Weather & Climate
  Discovery School History of the Earth
  Inside Planet Earth (Discovery)
  Living Rock (USGS)
  How the earth was made (History Channel)
  Faces of Earth (Science Channel)
  Your choices______________________
- **NBC Learn** news stories videos about earth structure and atmospheric events**…**and more.
- **Chapter PowerPoint's**
- **Student Workbook Assignments – Chapter 3**
- **Chapter and Lesson Assessments**
- **Chapter Quiz**

Optional DVD/Web-based suggestions:
YouTube Videos of Atmosphere and Earth's Layers:
https://www.youtube.com/watch?v=AV5T-40EG0U&list=PLF260DAA31E5ED448
https://www.youtube.com/watch?v=_iUfi8XqEos
https://www.youtube.com/watch?v=fyfN9t_E0w8
Layers of the Atmosphere
http://science.nationalgeographic.com/science/earth/earths-atmosphere/
https://docs.google.com/viewer?url=http%3A%2F%2Fwww.homeeducationresources.com%2Ffree%2FAtmosphereWorksheets.pdf
United States Geologic Survey:
http://www.usgs.gov/
Geology of New Jersey:
http://www.state.nj.us/dep/njgs/
http://www.state.nj.us/dep/njgs/enviroed/county-series/Atlantic_County.pdf
http://www.state.nj.us/dep/njgs/enviroed/freedwn/psnjmap.pdf
http://www.njgeology.org/enviroed/freedwn/HighlandsVFT.pdf

Cross-Curricular References/Projects:

ART Drawing and interpretation skills

Stage 1: Desired Results (Learning Targets)

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Standards (Include cross-curricular)

Science - NJ 2009 Core Curriculum Content Standards (NJCCCS)

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. (Grades: 9,10,11,12)
5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. (Grades: 9,10,11,12)
5.1.A Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. (Grades: 9,10,11,12)
5.1.A Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)
5.1.A Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. (Grades: 9,10,11,12)
5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. (Grades: 9,10,11,12)
5.1.B Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. (Grades: 9,10,11,12)
5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)
5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)
5.4 Earth Systems Science: Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe. (Grades: 9,10,11,12)
5.4.C Properties of Earth Materials: Earth's composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.1 Model the interrelationships among the spheres in the Earth systems by creating a flow chart. (Grades: 9,10,11,12)
5.4.C The chemical and physical properties of the vertical structure of the atmosphere support life on Earth. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.2 Analyze the vertical structure of Earth's atmosphere, and account for the global, regional, and local variations of these characteristics and their impact on life. (Grades: 9,10,11,12)
5.4.D Tectonics: The theory of plate tectonics provides a framework for understanding the dynamic processes within and on Earth. (Grades: 9,10,11,12)
5.4.D Convection currents in the upper mantle drive plate motion. Plates are pushed apart at spreading zones and pulled down into the crust at subduction zones. (Grades: 9,10,11,12)
5.4.D.5.4.12.D.1 Explain the mechanisms for plate motions using earthquake data, mathematics, and conceptual models. (Grades: 9,10,11,12)

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5.4.D Evidence from lava flows and ocean-floor rocks shows that Earth's magnetic field reverses (North - South) over geologic time. (Grades: 9,10,11,12)
5.4.D.5.4.12.D.2 Calculate the average rate of seafloor spreading using archived geomagnetic-reversals data. (Grades: 9,10,11,12)

Next Generation Science Standards (NGSS)

Earth Science – HSS-Earth Systems

HS-ESS2-2.	**Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.** [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]
HS-ESS2-3.	**Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.**[Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.]
HS-ESS1-5.	**Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.** [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).]
HS-ESS2-1.	**Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.** [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [*Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.*]

Other Cross-Curricular Standards

Writing techniques, essay and opinion papers, and grammar subjects. MLA/APA Citations
Reading Comprehension How to read scientific articles and news stories to get relevant evidence and information from them
History/Social Studies

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Enduring Understandings: (What Students will know) 8. How the Earth is composed. 9. That movement of the earth's crust causes earthquakes and volcanoes but also allows for other interactions that help allow life on Earth. 10. Understand the causes and consequences of human effects of Earth's Sphere's. 11. What our atmosphere is composed of and why our use of natural resources is damaging it. 12. Understand how negative and positive feedback loops affect Earth systems. 13. Certain environmental issues are problems are of concern for historians, geographers; civic leaders, economists and studying evidence from the past help us prevent future problems and make informed decisions that will better affect our future.	**Essential Questions** 1. What are the Earth's spheres? 2. What are negative and positive feedback loops? 3. What is Pangaea? 4. What happens at tectonic plate boundaries? 5. What are the Layers of the Atmosphere and why are each important? 6. What is the composition of element of the Atmosphere? 7. How do the spheres of the Earth interact?

Stage 2: Evidence of Learning

Performance Task 1 : (Poster Project) Illustrate the 'Spheres' of the Earth (as indicated in textbook) and label each and then add in exploded illustrations of the sub-various layers that are contained within each individual sphere and its relate the importance of each sphere and sub layer to humans. This exercise will require outside research and use of textbook. Scoring Rubric Included

Supplemental Performance Task 2: Mini-lab - illustrate the movement of Earth Plates.
Supplemental Performance Task 2: Water Cycle Mini-Lab (Textbook Pg 80)
Plate Tectonics http://www.cotf.edu/ete/modules/msese/earthsysflr/plates1.html
Worksheets: www.amnh.org/dinos_plate_tectonics.pdf

Worksheets:
http://rhoyle.cusd.claremont.edu/mm/Course%20Assets/Marine%20Biology/Assignments/pdf%20-%20Plate%20Tectonics%20worksheet.pdf

Plate Tectonics Animation: http://www.ucmp.berkeley.edu/geology/tectonics.html

DVD/Media Opinion Papers

Other evidence of learning:

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Chapter quiz Vocabulary – Student-centered worksheet/puzzles. Chapter Worksheets: Key concepts, Flow Charts, Open-ended questions, Student Participation: Student originated questions and debate about lecture topics, chapter issues and current news stories.

Stage 3: Learning Plan	
Objectives	
The Students will know: • The Earth's Five Spheres • Plate Tectonics • Where weather occurs • Layers of the Atmosphere • Water Cycle • Amount of water on the planet	**The Students will be able to (TSWBAT):** • Identify the how the earth is structured and what each sphere does. • Explain how humans are affected by changes in atmosphere composition. • Understand and explain how plate tectonics form the biosphere and cause earthquakes and volcanoes. • Explain how water is recycled throughout the atmosphere. • Understand the basic types of Geologic formations on Earth.

Learning Activities/Instructional Strategies	
Lesson	**Timeframe**
UNIT 2 Structure of the Earth **Key Terms:** feedback loop, erosi0n, geosphere, biosphere, atmosphere, hydrosphere, • Introduce the definition and importance of the Earth's Spheres. • Discussion on Essential Questions/Objectives • Lecture-PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheet • DVD-Earth Systems (Teacher Choice) • NBC Learn or YouTube selections on Atmosphere or Earth Layers	**2 day**
UNIT 2 Structure of the Earth • Student (individual or group) project. Illustrate and labeling the earth Spheres and their different sub-layers and importance to Humans	**2 days**
UNIT 2 Structure of the Earth and Chapters Assessments Chapter 3 lesson 3 **Key Terms:** Crust, mantle, core, tectonic plates, landform, deposition, hydrologic cycle, evaporation, precipitation, condensation, transpiration, aquifer, groundwater • Teacher/student activity about Earth, plate Tectonics, Earthquakes, Volcanoes, Ring-of-fire or water cycle. • Chapter quiz/test • Assess students skills and mastery of concepts and issues through use of : class discussion/debate, open-ended questions, multiple choice and essay.	**1 day**

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Individual Accommodations
• Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team. • Modified worksheets, quizzes and other assignments as required. • Provide enrichment assignments for early finishers. • Provide limited Extra Credit assignments. • Allow for additional time for different learning styles. • Differentiate instruction for varied learning styles. • Include technology into the classroom. • Allow for group interaction. • Encourage use 'flipped' classroom instruction by students. • Develop make-up assignments, quizzes and test as required. • ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature_________________________________
Date____________________

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UNIT 3 Biogeochemical Cycles	Number of Days: 14
Content Area: Environmental Science	

Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them. Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, biology, chemistry and the social sciences.

Many of our Objectives, lessons and essential questions will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world.

Unit 3 Biogeochemical Cycles will help student understand the how the Earth's basic elements are recycled throughout the systems of the planet for use by living (biotic) and non-living things (abiotic) thus learning the principle; law of conservation of matter; that matter can neither be created or destroyed but is converted for use. A **biogeochemical cycle** is the **cycling of substances** by which a chemical or elemental substance moves through both biotic (biosphere) and abiotic (lithosphere, atmosphere, and hydrosphere) compartments of Earth. A cycle is a series of change which comes back to the starting point and which can be repeated. Water, for example, is always recycled through the water cycle, as shown in the diagram. The water undergoes evaporation, condensation, and precipitation, falling back to Earth. Elements, chemical compounds, and other forms of matter are passed from one organism to another and from one part of the biosphere to another through biogeochemical cycles.

The term "biogeochemical" tells us that biological, geological and chemical factors are all involved. The circulation of chemical nutrients like carbon, oxygen, nitrogen, phosphorus, and water etc. through the biological and physical world are known as biogeochemical cycles. In effect, the element is recycled, although in some cycles there may be places (called *reservoirs*) where the element is accumulated or held for a long period of time (such as an ocean or lake for water)

Additionally students will learn what each is, how it functions and inter-relates to all life on Earth. Students will be able to understand feedback loops which are either negative or positive systems are used to describe environmental processes. Students will be able to integrate all of these concepts into developing informed in-class discussion/debates, opinion papers and presentations of the possible consequences of miss-use of natural or anthropogenic resources.

Grade Level: 9-12

21st Century Themes

	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

21st Century Skills

	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

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Materials/Equipment needed:

- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators
- Pearson Textbook and on-line/printed workbook
- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- maps
- ACHS Media Center – Gale Databases, library collections
- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

- **DVD: Suggested DVD's (select one or parts from one as time appropriate…)**
  How Ecosystems work: Energy flow and Nutrient cycles – www.greatpacificmedia.com)
  Your choices_______________________
- **NBC Learn** news stories videos about earth structure and atmospheric events…and more.
- **Chapter PowerPoint's**
- **Student Workbook Assignments – Chapter 3 – Lesson 4**
- **Chapter and Lesson Assessments**
- **Chapter Quiz**
- **Analyze Data and Ecological footprint exercise (textbook - page 95)**

Optional DVD/Web-based suggestions:
BioGeoChemical Cycles:
http://www.st.nmfs.noaa.gov/Assets/Nemo/documents/lessons/Lesson_4/Lesson_4-Teacher%27s_Guide.pdf
http://www.eoearth.org/view/article/150616/
http://www.eoearth.org/view/article/149760/
http://www.learner.org/courses/envsci/unit/text.php?unit=4&secNum=4
http://en.wikibooks.org/wiki/Ecology/Biogeochemical_cycles
https://eo.ucar.edu/kids/green/cycles1.htm
http://www.gov.mb.ca/conservation/sustain/cycle.pdf
https://www.youtube.com/watch?v=s-VY95SI0CI
https://www.youtube.com/watch?v=09_sWPxQymA
https://www.youtube.com/watch?v=rpohHGb1YUE
Teacher Choice

Carbon Cycle:
http://www.esrl.noaa.gov/research/themes/carbon/
http://www.esrl.noaa.gov/gsd/outreach/education/poet/CarbonCycle_print.pdf
http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/C/CarbonCycle.html
http://earthobservatory.nasa.gov/Features/CarbonCycle/
http://www.columbia.edu/~vjd1/carbon.htm
http://www.eoearth.org/view/article/150923/
Teacher Choice
Nitrogen Cycle:
https://www.youtube.com/watch?v=372K0jyO0hQ
http://www.nature.com/scitable/knowledge/library/the-nitrogen-cycle-processes-players-and-human-15644632

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http://www.pbslearningmedia.org/asset/lsps07_int_nitrogen/
http://www.physicalgeography.net/fundamentals/9s.html
Teacher Choice

Phosphorous Cycle:
https://www.youtube.com/watch?v=_IBx0zpNoEM
http://www.epa.gov/oecaagct/ag101/impactphosphorus.html
http://www.eoearth.org/view/article/155219/
http://www.sumanasinc.com/webcontent/animations/content/phosphorouscycle.html
http://water.epa.gov/type/rsl/monitoring/vms56.cfm
Teacher Choice

Cross-Curricular References/Projects:

ART Drawing and interpretation skills

Stage 1: Desired Results (Learning Targets)

Standards (Include cross-curricular)

Science - NJ 2009 Core Curriculum Content Standards (NJCCCS)

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. (Grades: 9,10,11,12)
5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. (Grades: 9,10,11,12)
5.1.A Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. (Grades: 9,10,11,12)
5.1.A Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)
5.1.A Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. (Grades: 9,10,11,12)
5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. (Grades: 9,10,11,12)
5.1.B Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. (Grades: 9,10,11,12)
5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)

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5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standard: **5.4** Earth Systems Science: Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe. (Grades: 9,10,11,12)

5.4.E Energy in Earth Systems: Internal and external sources of energy drive Earth systems. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.1 Model the interrelationships among the spheres in the Earth systems by creating a flow chart. (Grades: 9,10,11,12)
5.4.E.5.4.12.E.2 Predict what the impact on biogeochemical systems would be if there were an increase or decrease in internal and external energy. (Grades: 9,10,11,12)
5.4.G Biogeochemical Cycles: The biogeochemical cycles in the Earth systems include the flow of microscopic and macroscopic resources from one reservoir in the hydrosphere, geosphere, atmosphere, or biosphere to another, are driven by Earth's internal and external sources of energy, and are impacted by human activity. (Grades: 9,10,11,12)
5.4.G Natural and human-made chemicals circulate with water in the hydrologic cycle. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.1 Analyze and explain the sources and impact of a specific industry on a large body of water (Great Egg, Barnegat, Delaware or Chesapeake Bay). (Grades: 9,10,11,12)
5.4.G Natural ecosystems provide an array of basic functions that affect humans. These functions include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.2 Explain the unintended consequences of harvesting natural resources from an ecosystem. (Grades: 9,10,11,12)
5.4.G Movement of matter through Earth's system is driven by Earth's internal and external sources of energy and results in changes in the physical and chemical properties of the matter. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.3 Demonstrate, using models, how internal and external sources of energy drive the hydrologic, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles. (Grades: 9,10,11,12)
5.4.G Natural and human activities impact the cycling of matter and the flow of energy through ecosystems. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.4 Compare over time the impact of human activity on the cycling of matter and energy through ecosystems. (Grades: 9,10,11,12)
5.4.G Human activities have changed Earth's land, oceans, and atmosphere, as well as its populations of plant and animal species. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.5 Assess (using maps, local planning documents, and historical records) how the natural environment has changed since humans have inhabited the region. (Grades: 9,10,11,12)
5.4.G Scientific, economic, and other data can assist in assessing environmental risks and benefits associated with societal activity. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.6 Assess (using scientific, economic, and other data) the potential environmental impact of large-scale adoption of emerging technologies (e.g., wind farming, harnessing geothermal energy). (Grades: 9,10,11,12)
5.4.G Earth is a system in which chemical elements exist in fixed amounts and move through the solid Earth, oceans, atmosphere, and living things as part of geochemical cycles. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.7 Relate information to detailed models of the hydrologic, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles, identifying major sources, sinks, fluxes, and residence times. (Grades: 9,10,11,12)

Next Generation Science Standards (NGSS)

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Life Sciences LS2B Cycles of Matter and Energy Transfer in Ecosystems.

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps.*]

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.[Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

HS-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.[Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [*Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.*]

HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. [Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [*Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.*]

HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [*Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.*]

HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [*Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.*]

Earth Science – HSS-Earth Systems

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.[Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of include how photosynthetic life altered the atmosphere through the production of oxygen, which

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in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [*Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.*]

Other Cross-Curricular Standards

Writing techniques, essay and opinion papers, and grammar subjects. MLA/APA Citations
Reading Comprehension How to read scientific articles and news stories to get relevant evidence and information from them
History/Social Studies

Enduring Understandings:
(What Students will know)

14. How matter (elements/chemicals) are cycled in Earth systems.
15. How each biogeochemical cycle functions.
16. How humans can impact the each of the biogeochemical cycles.
17. How the sun provides the basic energy for Earth processes.
18. That without 'cycling' of matter the Earth would not function.

Essential Questions

1. What are Biogeochemical Cycles?
2. What is the law of conservation of matter?
3. What are common aspects of all the Carbon Cycle, Nitrogen Cycle, and Phosphorus Cycle?
4. How do each of these cycles differ?: Carbon Cycle, Nitrogen Cycle, Phosphorus Cycle.
5. How are humans affecting the carbon cycle?
6. What is the importance of nitrogen-fixing bacteria in the nitrogen cycle?
7. Why do producers need the photosynthesis process?
8. How does cellular respiration differ from photosynthesis?
9. What are producers, consumers, decomposers?

Stage 2: Evidence of Learning

Performance Task 1: (Poster and or PowerPoint Project) Illustrate each of the 'BioGeoChemical Cycles" of the Earth Individually (as indicated in textbook) and label each and then add the importance of each cycle and how each cycle can be impacted by humans. This exercise will require outside research and use of textbook. Scoring Rubric Included
Performance Task 2: Using individual or group participation the students will find two (2) current news stories (one (1) locally and one (1) anywhere in the world) about each of the cycles that describe how human impacts have affected the environment. Student should then express a written opinion 1-2 page opinion paper/essay)of what was happening in the news stories and how it could be related to the chapter's Central Case ("dead Zones") and how they would react to similar problem where they live and what could be done to stop or rectify the problem so it doesn't happen again? Scoring Rubric Included

Supplemental (optional) Performance Task 3: How can you apply your knowledge of the biogeochemical cycles to maintaining an aquarium? Pose this question to students and ask them to outline how each

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biogeochemical cycle impacts maintain an aquarium in their home or school.
Other evidence of learning: Chapter quiz Vocabulary – Student-centered worksheet/puzzles. Chapter Worksheets: Key concepts, Flow Charts, Open-ended questions, Student Participation: Student originated questions and debate about lecture topics, chapter issues and current news stories.

Stage 3: Learning Plan	
Objectives	
The Students will know: • Movement of matter through Earth's system is driven by Earth's internal and external sources of energy and results in changes in the physical and chemical properties of the matter. • The steps to the Carbon, Nitrogen and Phosphorous Cycles. • Know how bacteria can affect the Nitrogen cycle. • Law of conservation of matter. • Know how fertilizers create eutrophication of water bodies. • How bacteria "fix" nitrogen for use in soil from our atmosphere. • Scientific, economic, and other data can assist in assessing environmental risks and benefits associated with societal activity.	**The Students will be able to (TSWBAT):** • Explain why biogeochemical cycles are critical to life on Earth. • Describe and explain the Carbon Cycle. • Describe and explain the Nitrogen Cycle and importance of bacteria. • Describe and explain the Phosphorous Cycle • Describe and explain the Hydrologic (Water) Cycle • Explain the law of conservation of matter • Explain the impacts made by humans to these cycles. • Understand how information about the cycles can be applied to individuals. • Explain the Photosynthesis/Cellular Respiration process.

Learning Activities/Instructional Strategies	
Lesson	**Timeframe**
UNIT 3 BioGeoChemical Cycles (Overview) Chapter 3 – lesson 4 **Key Terms:** Law of conservation of matter, nutrient, biogeochemical cycle, primary producer, photosynthesis, consumer, decomposer, cellular respiration, eutrophication, nitrogen fixation. • Briefly review the hydrologic (Water Cycle and relate what students learned about that process and then introduce the definition and importance of the Earth's remaining biogeochemical cycles, using broad overview; Carbon, Nitrogen and Phosphorous. • Discussion on Essential Questions/Objectives • Lecture-PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword)	**3 days**

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• Student Worksheet • DVD-How Ecosystems work: Energy Flow and nutrient cycles or (Teacher Choice) • Web sites, NBC Learn or YouTube selections on biogeochemical cycles	
UNIT 3 BioGeoChemical Cycles - <u>Carbon</u> • Explanation of the Carbon Cycle using textbook and Internet examples. • Lecture-PowerPoint • YouTube or other internet visual on Carbon Cycle • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheet • In-class time (if allotted/available) for Student research for Performance Tasks. • 1-3 question open-ended assessment of cycle. (teacher choice)	**2 days**
UNIT 3 BioGeoChemical Cycles - <u>Nitrogen</u> • Explanation of the Nitrogen Cycle using textbook and Internet examples. • Lecture-PowerPoint • YouTube or other internet visual on Nitrogen Cycle • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheet • In-class time (if allotted/available) for Student research for Performance Tasks. • 1-3 question open-ended assessment of cycle. (teacher choice)	**3 days**
UNIT 3 BioGeoChemical Cycles - <u>Phosphorous</u> • Explanation of the Phosphorous Cycle using textbook and Internet examples. • Lecture-PowerPoint • YouTube or other internet visual on Phosphorous Cycle • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheet • In-class time (if allotted/available) for Student research for Performance Tasks. • 1-3 question open-ended assessment of cycle. (teacher choice)	**1 days**
UNIT 3 BioGeoChemical Cycles Performance Tasks 1 and 2 • Dedicated classroom time to develop individual or group Poster and or PowerPoint Projects about the BioGeoChemical Cycles. • Students will need: access to the Internet, materials for illustrating projects such as but not limited to art paper, markers, news stories, magazines and other media. Grades based upon supplied scoring rubric. • Chapter Quiz/test Assess students skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**3 days**

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Individual Accommodations
• Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team. • Modified worksheets, quizzes and other assignments as required. • Provide enrichment assignments for early finishers. • Provide limited Extra Credit assignments. • Allow for additional time for different learning styles. • Differentiate instruction for varied learning styles. • Include technology into the classroom. • Allow for group interaction. • Encourage use 'flipped' classroom instruction by students. • Develop make-up assignments, quizzes and test as required. • ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature_____________________________________
Date______________________

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UNIT 4 Ecology	Number of Days: 26
Content Area: Environmental Science	
Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them. Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, meteorology, botany, biology, chemistry and the social sciences. Many of our objectives, lessons and essential questions will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world. Unit 4 Ecology is the scientific study of interactions among organisms and their environment, such as the interactions organisms have with each other and with their abiotic environment, this differs from Environmental Science, which is the study of the effects humans have on the environment. Traditionally, Ecology is included as one aspect of understanding the environment before human interaction. Topics of interest to ecologists include the diversity, distribution, amount (biomass), number (population) of organisms, as well as competition between them within and among ecosystems. Ecosystems are composed of dynamically interacting parts including organisms, the communities they make up, and the non-living components of their environment. Ecosystem processes, such as primary production, net primary production, nutrient cycling, and various niche construction activities, regulate the flux of trophic energy and matter through an environment. These processes are sustained by organisms with specific life history traits, and the variety of organisms is called biodiversity. Biodiversity, which refers to the varieties of species, genes, and ecosystems, enhances certain ecosystem services. Ecosystems include; Biomes, and Aquatic Ecosystems which are broad categories to group a variety of similar ecosystems and most often also categorized by Climatograph analysis of climate conditions that separate their geographic locations and dictate vegetation or net primary production, terrain and animal populations. Ecology is an interdisciplinary field that includes biology or Life Science and Earth Science. Additionally students will learn what each is, how it functions and inter-relates to all life on Earth. Students will be able to understand feedback loops which are either negative or positive systems are used to describe environmental processes. Students will be able to integrate all of these concepts into developing informed in-class discussion/debates, opinion papers and presentations of the possible consequences of miss-use of natural or anthropogenic resources. **Unit 4 Ecology** has four (4) distinct lesson sections. All sections are covered under the same standards and have different timeframes. Each section closely follows the prescribed lessons and associated textbook chapters. **Ecology Populations, Evolution/Communities, Biomes and Aquatic Ecosystems, Biodiversity.**	
Grade Level: 9-12	
21st Century Themes	

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	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

21st Century Skills

	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

Materials/Equipment needed:

- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators
- Pearson Textbook and on-line/printed workbook
- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- Maps
- ACHS Media Center – Gale Databases, library collections
- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

- **DVD: Suggested DVD's (select one or parts from one as time appropriate…)**
  Populations: Biotic Potential (www.greatpacificmedia.com)
  Community Interactions: Predator/Prey/Symbiosis. (www.greatpacificmedia.com)
  Human Impact on Biosphere. (www.greatpacificmedia.com)
  Aquatic Biomes: Oceans, Rivers add Wetlands (www.greatpacificmedia.com)
  DVD Biology of lakes, ponds, streams and wetlands (BioMedia Associates)
  BIOME DVD's by Category (in ACHS Media collections)
  Evolution DVD (WGBH Boston Video)
  Hotspots DVD Biodiversity loss (PBS)
  Great Migrations (National Geographic)
  Planet Carnivore (National Geographic)
  Strange Days on Planet Earth Volumes 1&2 (National Geographic)
  Life in the Undergrowth (BBC Video)
  Silence of the Bees/Parrots in the land of Oz (Nature, PBS)
  The Silent Invasion (Oregon Public Broadcasting)
  TEACHER Selected/choice video/DVD

  Population Growth on-line Video: http://watchdocumentary.org/watch/crash-course-ecology-episode-02-population-ecology-the-texas-mosquito-mystery-video_d16749a1e.html
  Community Ecology: http://watchdocumentary.org/watch/crash-course-ecology-episode-04-community-ecology-feel-the-love-video_9e2eda206.html

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Ecology Relationships: http://watchdocumentary.org/watch/crash-course-ecology-episode-07-ecosystem-ecology-links-in-the-chain-video_07dc981de.html

Producers/Energy: http://watchdocumentary.org/watch/crash-course-ecology-episode-07-ecosystem-ecology-links-in-the-chain-video_07dc981de.html

Predator/Prey: http://watchdocumentary.org/watch/crash-course-ecology-episode-05-community-ecology-ii-predators-video_ef5e3ef1d.html

Succession: http://watchdocumentary.org/watch/crash-course-ecology-episode-06-ecological-succession-change-is-good-video_b90758a4a.html

Teacher Selected choices for on-line media.

- **NBC Learn** news stories videos about earth structure and atmospheric events**…**and more.
- **YouTube Videos** - (search appropriate topics)
- **Chapter or teacher generated PowerPoint lectures.**
- **Student Workbook Assignments**
- **Chapter and Lesson Assessments.**
- **Chapter Quiz/Test.**
- **Analyze Data and Ecological footprint exercises/Chapter Lesson**
- **Optional DVD/Web-based suggestions:**
  http://www.eoearth.org/view/article/155311/
  http://www.pbs.org/wgbh/nova/nature/population-ecology.html
- **Teacher Individual Choices as time permits.**

Cross-Curricular References/Projects:

ART: Drawing and interpretation skills
MATH: Graphing and calculating Carrying Capacity and Biodiversity
MATH: Age Structure Diagrams
MATH: Analyzing Graphs/Charts

Stage 1: Desired Results (Learning Targets)

Standards (Include cross-curricular)

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5.1.A Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. (Grades: 9,10,11,12)
5.1.A Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)
5.1.A Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. (Grades: 9,10,11,12)

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5.1.A.5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. (Grades: 9,10,11,12)
5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. (Grades: 9-12)
5.1.B Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. (Grades: 9,10,11,12)
5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)
5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standards: Life Science

5.3.B Matter and Energy Transformations: Food is required for energy and building cellular materials. Organisms in an ecosystem have different ways of obtaining food, and some organisms obtain their food directly from other organisms. (Grades: 9,10,11,12)
5.3.B As matter cycles and energy flows through different levels of organization within living systems (cells, organs, organisms, communities), and between living systems and the physical environment, chemical elements are recombined into different products. (Grades: 9,10,11,12)
5.3.B.5.3.12.B.1 Cite evidence that the transfer and transformation of matter and energy links organisms to one another and to their physical setting. (Grades: 9,10,11,12)
5.3.B Each recombination of matter and energy results in storage and dissipation of energy into the environment as heat. (Grades: 9,10,11,12)
5.3.B.5.3.12.B.2 Use mathematical formulas to justify the concept of an efficient diet. (Grades: 9,10,11,12)
5.3.B Continual input of energy from sunlight keeps matter and energy flowing through ecosystems. (Grades: 9,10,11,12)
5.3.B.5.3.12.B.3 Predict what would happen to an ecosystem if an energy source was removed. (Grades: 9,10,11,12)
5.3.B Plants have the capability to take energy from light to form sugar molecules containing carbon, hydrogen, and oxygen. (Grades: 9,10,11,12)
5.3.B.5.3.12.B.4 Explain how environmental factors (such as temperature, light intensity, and the amount of water available) can affect photosynthesis as an energy storing process. (Grades: 9,10,11,12)
5.3.B In both plant and animal cells, sugar is a source of energy and can be used to make other carbon-containing (organic) molecules. (Grades: 9,10,11,12)
5.3.B.5.3.12.B.5 Investigate and describe the complementary relationship (cycling of matter and flow of energy) between photosynthesis and cellular respiration. (Grades: 9,10,11,12)
5.3.B All organisms must break the high-energy chemical bonds in food molecules during cellular respiration to obtain the energy needed for life processes. (Grades: 9,10,11,12)
5.3.B.5.3.12.B.6 Explain how the process of cellular respiration is similar to the burning of fossil fuels. (Grades: 9,10,11,12)
5.3.C Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs. (Grades: 9,10,11,12)
5.3.C Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms. (Grades: 9,10,11,12)
5.3.C.5.3.12.C.1 Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem. (Grades: 9,10,11,12)
5.3.C Stability in an ecosystem can be disrupted by natural or human interactions. (Grades: 9,10,11,12)
5.3.C.5.3.12.C.2 Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations. (Grades: 9,10,11,12)

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5.3.E Evolution and Diversity: Sometimes, differences between organisms of the same kind provide advantages for surviving and reproducing in different environments. These selective differences may lead to dramatic changes in characteristics of organisms in a population over extremely long periods of time. (Grades: 9,10,11,12)
5.3.E New traits may result from new combinations of existing genes or from mutations of genes in reproductive cells within a population. (Grades: 9,10,11,12)
5.3.E.5.3.12.E.1 Account for the appearance of a novel trait that arose in a given population. (Grades: 9,10,11,12)
5.3.E The principles of evolution (including natural selection and common descent) provide a scientific explanation for the history of life on Earth as evidenced in the fossil record and in the similarities that exist within the diversity of existing organisms. (Grades: 9,10,11,12) **5.3.E.5.3.12.E.3** Provide a scientific explanation for the history of life on Earth using scientific evidence (e.g., fossil record, DNA, protein structures, etc.). (Grades: 9,10,11,12)
5.3.E Evolution occurs as a result of a combination of the following factors; Ability of a species to reproduce; Genetic variability of offspring due to mutation and recombination of genes; Finite supply of the resources required for life; Natural selection, due to environmental pressure, of those organisms better able to survive and leave offspring. (Grades: 9,10,11,12)
5.3.E.5.3.12.E.4 Account for the evolution of a species by citing specific evidence of biological mechanisms. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standards: Earth Science

5.4.E Energy in Earth Systems: Internal and external sources of energy drive Earth systems. (Grades: 9,10,11,12)
5.4.E The Sun is the major external source of energy for Earth's global energy budget. (Grades: 9,10,11,12)
5.4.E.5.4.12.E.2 Predict what the impact on biogeochemical systems would be if there were an increase or decrease in internal and external energy. (Grades: 9,10,11,12)

Next Generation Science Standards (NGSS)

Life Sciences LS2B Cycles of Matter and Energy Transfer in Ecosystems.

HS-LS1-5. **Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps.*]

HS-LS1-6. **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.**[Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

HS-LS1-7. **Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.**[Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [*Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.*]

HS-LS2-1.

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	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]
HS-LS2-2.	**Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]
HS-LS2-6.	**Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]
HS-LS2-7.	**Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]
HS-LS2-8.	**Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.**[Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]
HS-LS2-3.	**Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.** [Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [*Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.*]
HS-LS2-4.	**Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [*Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.*]
HS-LS2-5.	**Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.** [Clarification Statement: Examples of models could include simulations and mathematical models.] [*Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.*]
HS-LS2-6.	**Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as

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moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS2-8. **Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.**[Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.***[Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.

HS-LS4-1. **Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]

HS-LS4-2. **Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.** [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [*Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.*]

HS-LS4-3. **Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.** [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [*Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.*]

HS-LS4-4. **Construct an explanation based on evidence for how natural selection leads to adaptation of populations.**[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

HS-LS4-5. **Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.** [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the

	environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]
Enduring Understandings: <u>(What Students will know)</u> 19. How Ecology differs from Environmental Science. 20. How changes in population sizes can affect the environment. 21. How organisms affect one another's survival, reproduction and their environment. 22. How species evolve and adapt within ecosystems. 23. How species/organism interact with each other, nature and man. 24. How ecological disturbances change the environment. 25. How energy is transferred among species in ecosystems. 26. How conditions around the world determine where species live and survive. 27. How as we travel in the world conditions change with location. 28. That ecosystem biodiversity health is crucial for human sustainability.	**Essential Questions** • What are producers, consumers, decomposers? • What are the ecological levels or organizations? • What is population density and distribution? • How does it affect the ecosystem? • What is Carrying Capacity? • What is the distinction between biotic and abiotic factors in an ecosystem? • What is the distinction between habitat and niche? • What are the five major types of species interactions and what are examples of each type? • How does the process of evolution by natural selection work? • What is coevolution? • What is extinction? • What are the relationships between species in Predator-Prey, Mutualism and Commensalism? • Discuss Trophic levels and energy transfer and the 10% rule. • Differentiate between food chains & food webs. • Describe ecological succession. • What are invasive species and what is their effect on ecosystems? • What is a biome? • What is Climotgraph? • How are plants and animals adapted to life in each kind of forest biome? • What are the characteristics of the different freshwater ecosystems? • How do organisms adapt to survive in moving and standing freshwater ecosystems? What are

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	the characteristics of estuaries, coral reefs, oceans, and polar ecosystems? • Explain the importance of estuaries. • List the major zones within the ocean. • What is Biodiversity and how does it contribute to life on earth. • Why is biodiversity at risk? • What are endangered, threatened or extinct species? • How do we currently protect species and biodiversity? • What are biodiversity hotspots

Stage 2: Evidence of Learning

Performance Task 1 Populations: Essay (2 pages typed and researched) about why populations change and affect their environments or are affected by changing conditions in their environments. Use textbook Central Case as primary example but require students to find other examples. Requires use of Internet or media center. **Scoring Rubric Included**

Performance Task 2 Evolution & Communities: Find three different news/scholarly articles about invasive species in New Jersey and write a one page summary of each article including the student opinion and comments. This exercise will require outside research and use of textbook. **Scoring Rubric Included**

Performance Task 3 Evolution & Communities (Poster and/or PowerPoint Project) Illustrate a typical food web with a desired local ecosystem; such as estuary, marsh, river or steam, bay beach, pine forest, farm, urban area (city block or park) **Scoring Rubric Included**

Performance Task 4 BIOMES : (Poster and/or PowerPoint Project) Students are assigned or can select a specific Biome or Aquatic Ecosystem to Illustrate as a poster or PowerPoint (as indicated in textbook) and include a typical climatograph of that biome, a selection of plants and animals and how that biome can be impacted by humans. This exercise will require outside research and use of textbook. Teacher defines parameters of the performance task. **Scoring Rubric Included**

Performance Task 5 Biodiversity: Research Paper (2-3 pages typed and researched) about threats to biodiversity in New Jersey by changing conditions in the environments and how this might affect the human population. Requires use of Internet or media center. **Scoring Rubric Included**
Some research options:
http://www.state.nj.us/dep/dsr/publications/pinelands-final.pdf or
http://www.conservewildlifenj.org/species/threats/
http://www.nj.gov/dep/newsrel/2012/12_0015.htm
http://www.state.nj.us/dep/fgw/ensphome.htm
http://www.nj.gov/dep/dsr/trends/pdfs/endangered-plant.pdf
http://www.state.nj.us/pinelands/
http://www.pinelandsalliance.org/

Performance Task 6 Biodiversity: LAB Biodiversity. List the extinct, endangered or threatened species around the world in the past 10 years. Explain the reasons why species are on this list. This can be written or discussed in-class with appropriate research. Requires use of Internet or media center.
Scoring Rubric Included
Links: http://www.iucnredlist.org/
https://www.worldwildlife.org/species/directory?direction=desc&sort=extinction_status

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http://www.fws.gov/endangered/ http://www.earthsendangered.com/list.asp **Supplemental (optional) Performance Task - Populations:** LAB: Calculate Population Growth Rate for specific ecosystem using: birth-death rates, immigration-emigration, migration data. Then graph the data. (Math exercise) **Supplemental (optional) Performance Task – Current events that impact evolution, populations, biomes, invasive species, succession due to Super Storm Sandy.** Requires student imagination, discussion, teacher guidance and research with use of Internet or media center. **Scoring Rubric Included**
Other evidence of learning: Chapter Quiz and Test Vocabulary – Student-centered worksheet/puzzles. Chapter Worksheets: Key concepts, Flow Charts, Open-ended questions, Student Participation: Student originated questions and debate about lecture topics, chapter issues and current news stories.

<table>
<tr><th colspan="2">Stage 3: Learning Plan</th></tr>
<tr><th colspan="2">Objectives</th></tr>
<tr><td>The Students will know:
How scientists organize or categorize life (species)
Why successful populations need biotic and abiotic factors for growth.
How available resources determine population growth and size
Relationships between species in different ecosystems.
That life requires energy and it does this through food chains and food webs and energy transfer among species.
How species evolve and adapt to local conditions.
Biomes are determined by location on the planet, their climate and vegetation.
Understand why some biomes are more diverse in species than others
That an aquatic ecosystem is different than a terrestrial biome and is categorized by salinity, depth and whether it is moving water or standing water.
Understand what Biodiversity is why it is critical to the sustainability of life.</td>
<td>The Students will be able to (TSWBAT):
Identify the levels of ecological organization.
Analyze how natural resources can affect the population growth of a species in any habitat or ecosystem.
Demonstrate how to analyze populations using age structure diagrams and graphs.
Demonstrate a basic understanding of how evolution can occur and how species adapt to local conditions.
Analyze the relationship between species within an ecosystem and how energy is transferred among trophic levels.
Certain species are critical or key to a community.
How photosynthesis works.
Understand the 10% rule of energy in trophic energy pyramids.
That disturbance to communities within ecosystems can experience succession.
Understand the some species are invasive and can cause ecosystems to fail by their presence.
Biomes are determined by latitude, climate and vegetation.
Understand how to interpret a climatograph to identify a biome.
Identify the types of aquatic ecosytems.
Understand the importance of aquatic ecosystems to the environment.</td></tr>
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	• Identify the different types of species biodiversity and its distribution in habitats, ecosystems and biomes. • Discuss the benefits of biodiversity. • Analyze the causes and consequences of biodiversity loss.

Learning Activities/Instructional Strategies	
Lesson	**Timeframe**
UNIT 4 ECOLOGY - Populations Chapter 4 **Key Terms:** Definition of Ecology, Biotic-abiotic, habitat, Population, density, distribution, age structure diagrams, Immigration-emigration, migration, survivorship curves, exponential growth, birth-death rates • Teacher centered lecture on **Lesson 1 page 100-123** • Lecture-PowerPoint (teacher generated or textbook) • Discussion on Essential Questions/Objectives • Central Case – Cloud Forest in Costa Rica. • Develop web-based supplemental information. • **Performance Task 1** Essay about why populations change and affect their environments or are affected by changing conditions in their environments. • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets, homework, in-class assignments • DVD-Populations: Biotic Potential or (Teacher Choice) • **http://watchdocumentary.org/watch/crash-course-ecology-episode-02-population-ecology-the-texas-mosquito-mystery-video_d16749a1e.html** • Web sites, NBC Learn or YouTube selections on Ecological populations. • LAB – teacher selection. (optional) • Periodic assessment of learning. (teacher choice) • **Supplemental (optional) Performance Task - Populations:** LAB: Calculate Population Growth Rate for specific ecosystem using: birth-death rates, immigration-emigration, migration data. Then graph the data. (Math exercise)	**5 days**
UNIT 4 ECOLOGY - Evolution and Community Relationships Chapter 5 **Key Terms:** Evolution-Natural Selection, Species relationships, Food webs-chains, trophic energy transfer, succession, Invasive Species. • Lecture-PowerPoint (teacher generated or textbook) on lesson 2 pages **124-161** • Student discussion/debate on evolution/natural selection and adaptations to environments. • Discussion on Essential Questions/Objectives • Central Case – Black & White and Spread All Over (Zebra Mussels) • Develop web-based supplemental information. • LAB – Teacher selected (Optional) • DVD teacher selection or choose from list below: Community Interactions: Predator/Prey/Symbiosis (www.greatpacificmedia.com) Great Migrations (National Geographic) Planet Carnivore (National Geographic) Strange Days on Planet Earth Volumes 1&2 (National Geographic)	**9 days**

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Life in the Undergrowth (BBC Video) Silence of the Bees/Parrots in the land of Oz (Nature, PBS) The Silent Invasion (Oregon Public Broadcasting) • NBC Learn or YouTube or other internet visual on evolution debate, invasive species, succession or food web-chains. • **Performance Task 2 Evolution & Communities:** Find three different news/scholarly articles about invasive species in New Jersey and write a one page summary of each article including the student opinion and comments. This exercise will require outside research and use of textbook. **Scoring Rubric Included** • **Performance Task 3 Evolution & Communities** (Poster and/or PowerPoint Project) Illustrate a typical food web with a desired local ecosystem; such as estuary, marsh, river or steam, bay beach, pine forest, farm, urban area (city block or park) **Scoring Rubric Included** • **On-line Resources:** **Community Ecology:** http://watchdocumentary.org/watch/crash-course-ecology-episode-04-community-ecology-feel-the-love-video_9e2eda206.html **Ecology Relationships:** http://watchdocumentary.org/watch/crash-course-ecology-episode-07-ecosystem-ecology-links-in-the-chain-video_07dc981de.html **Producers/Energy:** http://watchdocumentary.org/watch/crash-course-ecology-episode-07-ecosystem-ecology-links-in-the-chain-video_07dc981de.html **Predator/Prey:** http://watchdocumentary.org/watch/crash-course-ecology-episode-05-community-ecology-ii-predators-video_ef5e3ef1d.html **Succession:** http://watchdocumentary.org/watch/crash-course-ecology-episode-06-ecological-succession-change-is-good-video_b90758a4a.html • In-class time (if allotted/available) for Student research for Performance Tasks. • Periodic assessment of learning. (teacher choice)	
UNIT 4 ECOLOGY - BIOMES & Aquatic Ecosystems Chapter 6 **Key Terms:** Biome, climate, weather, climatograph, net primary production, canopy, emergent layer, understory, epiphytes, deciduous, coniferous, hibernation, permafrost, salinity, photic-aphotic-benthic zones, littoral and limnetic zones, wetlands, flood plains, estuaries and upwelling. • **Lesson 3 Textbook Chapter pages 162-197** • Lecture-PowerPoint (teacher generated or textbook) • Discussion on Essential Questions/Objectives. • Central Case – Too Much of a Good Thing • Develop web-based supplemental information. • YouTube or other internet visual on Biomes. • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets, homework, in-class assignments • LAB – Teacher selected • DVD teacher selection or choose from the list below: Aquatic Biomes: Oceans, Rivers add Wetlands (www.greatpacificmedia.com) DVD Biology of lakes, ponds, streams and wetlands (BioMedia Associates) BIOME DVD's by Category (in ACHS Media collections)	**7 days**

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• **Performance Task 4 BIOMES :** (Poster and/or PowerPoint Project) Students are assigned or can select a specific Biome or Aquatic Ecosystem to Illustrate as a poster or PowerPoint (as indicated in textbook) and include a typical climatograph of that biome, a selection of plants and animals and how that biome can be impacted by humans. This exercise will require outside research and use of textbook. Teacher defines parameters of the performance task. **Scoring Rubric Included** • In-class time (if allotted/available) for Student research for Performance Tasks. • Chapter assessment. (teacher choice)	
UNIT 4 ECOLOGY - Biodiversity Chapter 7 **Key Terms:** Biodiversity, species diversity, genetic diversity, ecosystem diversity, extirpation, endangered and threatened species, habitat fragmentation, poaching, Endangered Species ACT (ESA), Convention on International Trade in Endangered Species of Wild Fauna and Flora. (CITES), biodiversity hotspot, endemic, • **Lesson 4 Textbook Chapter pages 198-224** • Teacher generated Lecture-PowerPoint. • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets, homework, in-class assignments. • LAB – Teacher selected • Central Case – Saving the Siberian Tiger. http://animals.nationalgeographic.com/animals/mammals/siberian-tiger/ • http://www.worldwildlife.org/species/amur-tiger • In-class time (if allotted/available) for Student research for Performance Tasks. • YouTube or other internet visual on Biodiversity, hotspots, endangered or threatened or extinct species • DVD teacher selected or choose from list below: Human Impact on Biosphere**.** (www.greatpacificmedia.com) *Hotspots* **DVD Biodiversity loss** (PBS) • **Performance Task 5 Biodiversity:** Research Paper (2-3 pages typed and researched) about threats to biodiversity in New Jersey by changing conditions in the environments and how this might affect the human population. Requires use of Internet or media center. **Scoring Rubric Included** • **Performance Task 6 Biodiversity: LAB Biodiversity.** List the extinct, endangered or threatened species around the world in the past 10 years. Explain the reasons why species are on this list. This can be written or discussed in-class with appropriate research. Requires use of Internet or media center. **Scoring Rubric Included** • Chapter and Unit assessment of cycle. (teacher choice)	**8 days**
UNIT 4 ECOLOGY Unit Final Assessments • **Supplemental Performance Task – Current events that impact evolution, populations, biomes, invasive species, succession due to the effects of Super Storm Sandy in New Jersey.** Requires student imagination, discussion, teacher guidance and research with use of Internet or media center. **Scoring Rubric Included** • Dedicated classroom time to complete individual or group Supplemental Performance Task for the Unit ECOLOGY, lesson 1-4	**3 days**

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• Students will need: access to the Internet, materials for illustrating projects such as but not limited to art paper, markers, news stories, magazines and other media. Grades based upon supplied scoring rubric. • Chapter Quiz/test	

Individual Accommodations
• Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team. • Modified worksheets, quizzes and other assignments as required. • Provide enrichment assignments for early finishers. • Provide limited Extra Credit assignments. • Allow for additional time for different learning styles. • Differentiate instruction for varied learning styles. • Include technology into the classroom. • Allow for group interaction. • Encourage use 'flipped' classroom instruction by students. • Develop make-up assignments, quizzes and test as required. • ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature____

Date______________________

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UNIT 5 The Human Population	Number of Days: 8

Content Area: Environmental Science

Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them. Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, meteorology, botany, biology, chemistry and the social sciences.

Many of our objectives, lessons and essential questions will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world.

UNIT 6 Human Population 7 billion people now live on planet Earth…and growing at the rate of 1 birth every 8 seconds and I death every 13 seconds. This ratio is critical to understanding human populations just as it is with understanding animals in ecosystems. This lesson covers factors like: education, technology, medicine, agriculture, industry, sanitation and cultural worldview that impact human growth or Demography. The section covers how population changes by country and the wealth of each nation and their education level.

Grade Level: 9-12

21st Century Themes

	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

21st Century Skills

	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

Materials/Equipment needed:

- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators
- Pearson Textbook and on-line/printed workbook
- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- maps
- ACHS Media Center – Gale Databases, library collections
- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

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- **DVD: Suggested DVD's (select one or parts from one as time appropriate…)**
  World in the Balance – The Population Paradox (NOVA)
  After People (History Channel)
- World of 7 Billion On-Line Video: http://www.worldof7billion.org/images/uploads/DVD.pdf
  TED Talks: Hans Rosling Population Growth:
  https://www.ted.com/talks/hans_rosling_on_global_population_growth
  http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen

- Your choices_______________________
- **NBC Learn** news stories videos about earth structure and atmospheric events…and more.
- **Chapter PowerPoint's**
- **Student Workbook Assignments – Chapter 3**
- **Chapter and Lesson Assessments**
- **Chapter Quiz**

Optional DVD/Web-based suggestions:
Web Sites:
http://www.census.gov/popclock/
7 Revolutions: https://www.youtube.com/watch?v=xkrJH9tt4qQ&feature=related
NJ Census Quick Facts http://quickfacts.census.gov/qfd/states/34000.html
Atlantic City Census Quick Facts http://quickfacts.census.gov/qfd/states/34/3402080.html
YouTube Videos of: human population
Filling Up! NPR https://www.youtube.com/watch?v=VcSX4ytEfcE
7 Billion and Counting https://www.youtube.com/watch?v=d1dIAtvSFLM
Paul Ehrlich - Population, Environment, and the Millennium Alliance for Humanity and the Biosphere
75 mins. **https://www.youtube.com/watch?v=YHc7-275h0Y**

Cross-Curricular References/Projects:

ART Drawing and interpretation skills
Math: calculating population growth rates, graphing and data table analysis.

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Stage 1: Desired Results (Learning Targets)

Standards (Include cross-curricular)

Science - NJ 2009 Core Curriculum Content Standards (NJCCCS)

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. (Grades: 9,10,11,12)
5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. (Grades: 9,10,11,12)
5.1.A Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. (Grades: 9,10,11,12)
5.1.A Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)
5.1.A Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. (Grades: 9,10,11,12)
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5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. (Grades: 9,10,11,12)
5.1.B Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. (Grades: 9,10,11,12)
5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)
5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standards: **5.3** Life Science: Life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics. (Grades: 9,10,11,12)
5.3.C Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs. (Grades: 9,10,11,12)
5.3.C Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms. (Grades: 9,10,11,12)

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5.3.C.5.3.12.C.1 Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem.
(Grades: 9,10,11,12)
5.3.C Stability in an ecosystem can be disrupted by natural or human interactions.
(Grades: 9,10,11,12)
5.3.C.5.3.12.C.2 Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations. (Grades: 9,10,11,12)

5.10.5.10.12 B.2 Use scientific, economic, and other data to assess environmental risks and benefits associated with societal activity. (Grades: 9,10,11,12)

Next Generation Science Standards (NGSS)

Life Science: HS.Natural Selection and Evolution

Students who demonstrate understanding can:

HS-LS4-1. **Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]

HS-LS4-2. **Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.** [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [*Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.*]

HS-LS4-3. **Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.** [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [*Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.*]

HS-LS4-4. **Construct an explanation based on evidence for how natural selection leads to adaptation of populations.**[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

HS-LS4-5. **Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.** [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

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Life Science: HS.Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

HS-LS2-1. **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]

HS-LS2-2. **Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]

HS-LS2-6. **Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS2-8. **Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.**[Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.***[Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

Other Cross-Curricular Standards
Math, calculating population growth, graphs, charts and statistics.
Writing techniques, essay and opinion papers, and grammar subjects. MLA/APA Citations
Reading Comprehension How to read scientific articles and news stories to get relevant evidence and information from them
History/Social Studies, history of world overview, agricultural & industrial revolutions, dust bowl

Enduring Understandings: (What Students will know)	**Essential Questions** • What are the 3 major population processes?

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• Most of the world's population is highly clustered in four regions: East Asia, South Asia, Europe, and Southeast Asia. • Virtually all the world's natural population increase is concentrated in the developing countries of Africa, Asia, and Latin America. • Regional population growth varies based on the rates of births, deaths, and natural increase. • Political, social, economic, and environmental factors interact to determine these varying rates. • Migration can be international (voluntary or forced) or internal (interregional or intraregional). • There are many types of migration: transnational, internal, chain, step, seasonal agriculture, rural to urban, urban to suburban, and urban to rural. • People migrate for a combination of political, environmental, and economic push and pull factors. • There are both positive and negative economic, social, political, and environmental consequences of migration that greatly impact human societies. • Understand how some human choices about population growth, resource use, population distribution, overconsumption, the capacity of technology to solve problems, poverty, the role of economics, and politics affect the quality and quantity of life.	• How does population growth and decline affect societies? • What is urbanization? • Where is the world's population distributed? • Why is global population increasing? • Why does population growth vary among regions? • Where are migrants distributed? • Where do people migrate? Why do people migrate? • What are the obstacles faced by migrants? • What are the economic, social, political, and environmental consequences of migration?

Stage 2: Evidence of Learning

Performance Task 1 : Compare Population growth rates and demographic data for Atlantic City, New Jersey and the United State by analyzing census data and developing reasons why certain areas have different growth rates, economic, education and financial factors

US Census http://www.census.gov/popclock/

NJ Census Quick Facts http://quickfacts.census.gov/qfd/states/34000.html

Atlantic City Census Quick Facts http://quickfacts.census.gov/qfd/states/34/3402080.html
Scoring Rubric Included

Performance Task 2: Mini-lab – Build and Compare Age structure diagrams. Page 237 Textbook.

DVD/Media Opinion Papers

Other evidence of learning:
Chapter quiz
Vocabulary – Student-centered worksheet/puzzles.

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Chapter Worksheets: Key concepts, Flow Charts, Open-ended questions, Student Participation: Student originated questions and debate about lecture topics, chapter issues and current news stories.

Stage 3: Learning Plan	
Objectives	
The Students will know: • How a population grows • Factors that affect population growth • Developed-developing countries • Life expectancy • demography • Age structure diagrams	**The Students will be able to (TSWBAT):** • identify the three population processes. • relate the ideas of Thomas Malthus to population changes. • predict world population trends. • trace the development of preindustrial and modern cities. • compare and contrast four theories of city growth.

Learning Activities/Instructional Strategies	
Lesson	**Timeframe**
UNIT 5 Human Population - Chapter 8 Lesson 1 **Key Terms:** Industrial Revolution, infant mortality, life expectancy, growth rate, demography • Introduce the definition and importance of the industrial and agricultural revolutions to human population growth over time. • Discussion on Essential Questions/Objectives • Teacher or textbook based-Lecture-PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheet • DVD-People Paradox • NBC Learn or YouTube selections on Human Population Growth	**3 days**
UNIT 5 Human Population – Chapter 8 Lesson 2 **Key Terms:** TFR-Total fertility rate, replacement fertility, demographic transition • Lecture about age structure diagrams and demographic transitions • Student discussion on One Child Policy in China • Student discussion on developing and developed nations and social factors. • Student in-class or homework workbook assignments • **Performance Task 1** : Compare Population growth rates and demographic data for Atlantic City, New Jersey and the United State by analyzing census data and developing reasons why certain areas have different growth rates, economic, education and financial factors US Census http://www.census.gov/popclock/NJ	**3 days**

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Census Quick Facts http://quickfacts.census.gov/qfd/states/34000.htmlhttp://quickfacts.census.gov/qfd/states/34/3402080.html Scoring Rubric Included • **Performance Task 2: Mini-lab –** Build and Compare Age structure diagrams. Page 237 Textbook.	
UNIT 5 Human Population – Chapter 8 Lesson 3 **Key Terms:** Wealth GAP. • Discussion about human footprint of various countries of the world and their comparison between wealth, technology and education. • Chapter quiz/test • Assess students skills and mastery of concepts and issues through use of : class discussion/debate, open-ended questions, multiple choice and essay.	**1 day**

Individual Accommodations

- Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team.
- Modified worksheets, quizzes and other assignments as required.
- Provide enrichment assignments for early finishers.
- Provide limited Extra Credit assignments.
- Allow for additional time for different learning styles.
- Differentiate instruction for varied learning styles.
- Include technology into the classroom.
- Allow for group interaction.
- Encourage use ‘flipped’ classroom instruction by students.
- Develop make-up assignments, quizzes and test as required.
- ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature_______________________________________
Date______________________

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UNIT 6 Human Health and the Environment	Number of Days: 12
Content Area: Environmental Science	

Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, meteorology, botany, biology, chemistry and the social sciences.

Many of our objectives, lessons and essential questions will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world.

UNIT 5 Environmental and Human Health will help student understand the environmental factors can affect human health and our quality of life. Factors include; Natural disaster-Hurricanes and severe storms, volcanoes, earthquakes. To other factors like over-exposure to sun's rays, auto exhaust, human-made chemical-compounds. There are four types of environmental hazards: Physical, chemical, social and biological. Students will learn about key concepts, persons and history of environmental health. Students will use; case studies, scientific documents, essays, video documentaries, news stories, textbook assignments, lab experiment and lecture and group discussion and debate to develop their place in the environment.

Additionally students will learn the scientific method of solving issues in science and the environment as a process in decision-making, observation and interpretation. They will understand how their worldview and culture helps determine opinions and ethical standards in their lives and others. Students will understand how legal, economic and governmental issues and agencies affect environmental policies, decisions and how the government interacts with citizens and other countries to solve environmental issues. Students will use decision-making processes to solve critical environmental issues and be able to understand how graphs, data tables and open/closed systems are used to describe environmental systems.

Students will be able to integrate all of these concepts into developing informed in-class discussion/debates, opinion papers and presentations of the possible consequences of miss-use of natural or anthropogenic resources.

Grade Level: 9-12

21st Century Themes

	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

21st Century Skills

	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

Materials/Equipment needed:

- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators

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- Pearson Textbook and on-line/printed workbook
- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- Maps, charts and graphs
- ACHS Media Center – Gale Databases, library collections
- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

- **DVD:** One DVD each to illustrate/explain Human Health
  Teacher choice or from the list below:
  Ebola: The Plague Fighters (Nova)
  The Virus Hunters (National Geographic)
  Contagion (Warner Bros.)
  Optional Natural Disaster DVD's:
  Witness: Disaster in Japan (National Geographic)
  Tsunami that Shook the World (WGBH Boston)
  Hurricane Katrina – A Storm that Drowned a City. (NOVA)
  Twister (Warner Bros)
  Last Days on Earth (ABC News)

- **NBC Learn** news stories videos: search: Science/Biology/Bacteria & Viruses and more.
- **Chapter PowerPoint's** (Teacher designed or textbook provided)
- **Student Workbook Assignments – Chapters 9 Environmental Health**
- **Chapter homework, in-class and other Lesson Assignments**
- **Essays-Research Paper/Opinion Papers:**
- **Chapter Assessments: Quizzes/Tests, teacher designed.**
- **LABS: designed by chapter as needed**
- **Performance Tasks**
- **Selected web sites:**
  USGS: http://health.usgs.gov/
  EPA: http://water.epa.gov/scitech/swguidance/standards/criteria/health/
  http://www.epa.gov/climatechange/impacts-adaptation/health.html
  http://www.epa.gov/greenkit/health4.htm
  Environment and Human Health: http://www.ehhi.org/
  CDC: http://www.cdc.gov/nceh/ehhe/
  WHO: http://www.who.int/phe/health_topics/en/
  Clean Air Council:
  http://www.cleanair.org/program/environmental_health/childrens_environmental_health/environmental_health_hazards
  http://www.thehastingscenter.org/Publications/BriefingBook/Detail.aspx?id=2170
  Natural Disasters:
  http://environment.nationalgeographic.com/environment/natural-disasters/
  http://www.ready.gov/natural-disasters
  http://www.bt.cdc.gov/disasters/

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http://www.huffingtonpost.com/news/natural-disasters/
http://www.sciencedaily.com/news/earth_climate/natural_disasters/
Teacher selected/choice web sites.

- **Optional DVD/Web-based suggestions:**
  Environmental Issues and Human Impact (www.cambridgeeducational.com)
  http://www.motherearthnews.com/natural-health/health-hazards-factory-farms-zmaz09fmzraw.aspx#axzz37k3ooLmk
- http://www.scientificamerican.com/article/ultimate-social-network-bacteria-protects-health/

Cross-Curricular References/Projects:
HISTORY

- Center for disease Control (CDC)
- World Health Organization. (WHO)

Stage 1: Desired Results (Learning Targets)

Standards (Include cross-curricular)

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5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)
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5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)

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5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)
5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)
5.1.C Reflect on Scientific Knowledge: Scientific knowledge builds on itself over time. (Grades: 9,10,11,12)
5.1.C Refinement of understandings, explanations, and models occurs as new evidence is incorporated. (Grades: 9,10,11,12)
5.1.C.5.1.12.C.1 Reflect on and revise understandings as new evidence emerges. (Grades: 9,10,11,12)
5.1.C Data and refined models are used to revise predictions and explanations. (Grades: 9,10,11,12)
5.1.C.5.1.12.C.2 Use data representations and new models to revise predictions and explanations. (Grades: 9,10,11,12)
5.1.C Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges. (Grades: 9,10,11,12)
5.1.C.5.1.12.C.3 Consider alternative theories to interpret and evaluate evidence-based arguments. (Grades: 9,10,11,12)
5.1.D Participate Productively in Science: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms. (Grades: 9,10,11,12)
5.1.D Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work. (Grades: 9,10,11,12)
5.1.D.5.1.12.D.1 Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. (Grades: 9,10,11,12)
5.1.D Science involves using language, both oral and written, as a tool for making thinking public. (Grades: 9,10,11,12)
5.1.D.5.1.12.D.2 Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. (Grades: 9,10,11,12)
5.1.D Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically. (Grades: 9,10,11,12)
5.1.D.5.1.12.D.3 Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standards: **5.3 Life Science**:
Life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics. (Grades: 9,10,11,12)
5.3.B As matter cycles and energy flows through different levels of organization within living systems (cells, organs, organisms, communities), and between living systems and the physical environment, chemical elements are recombined into different products. (Grades: 9,10,11,12)
5.3.B.5.3.12.B.1 Cite evidence that the transfer and transformation of matter and energy links organisms to one another and to their physical setting. (Grades: 9,10,11,12)
5.3.C Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs. (Grades: 9,10,11,12)
5.3.C Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms. (Grades: 9,10,11,12)
5.3.C.5.3.12.C.1 Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem. (Grades: 9,10,11,12)

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5.3.C Stability in an ecosystem can be disrupted by natural or human interactions. (Grades: 9,10,11,12)
5.3.C.5.3.12.C.2 Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standards: **5.4 Earth Systems Science:** Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe. (Grades: 9,10,11,12)
5.4.G Natural and human-made chemicals circulate with water in the hydrologic cycle. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.1 Analyze and explain the sources and impact of a specific industry on a large body of water (e.g., Delaware or Chesapeake Bay). (Grades: 9,10,11,12)
5.4.G Natural ecosystems provide an array of basic functions that affect humans. These functions include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.2 Explain the unintended consequences of harvesting natural resources from an ecosystem. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.5 Assess (using maps, local planning documents, and historical records) how the natural environment has changed since humans have inhabited the region. (Grades: 9,10,11,12)
5.4.G Scientific, economic, and other data can assist in assessing environmental risks and benefits associated with societal activity. (Grades: 9,10,11,12)
5.4.G.5.4.12.G.6 Assess (using scientific, economic, and other data) the potential environmental impact of large-scale adoption of emerging technologies (e.g., wind farming, harnessing geothermal energy). (Grades: 9,10,11,12)

Next Generation Science Standards NGSS

HS. Interdependent Relationships in Ecosystems

HS-LS2-1. **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]

HS-LS2-2. **Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]

HS-LS2-6. **Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

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HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS2-8. **Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.**[Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.***[Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-1. **Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

HS-ESS3-3. **Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.** [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [*Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.*]

HS-ESS3-4. **Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geo-engineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-5. **Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.*]

HS-ESS3-6. **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism

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health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

HS-ETS1 Engineering Design

Students who demonstrate understanding can:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Other Standards:
Writing techniques, essay and opinion papers, and grammar subjects. MLA/APA Citations
Reading Comprehension Skills
History/Social Studies. Emergent Disease and past epidemics and pandemics

Enduring Understandings: (What Students will know).	**Essential Questions**
29. Knowing cause and effect and dose and dose-response will help us make better informed decisions about human health. 30. Physical events and chemical hazards in the environment affect human health. 31. Individuals respond differently to the same environmental hazards	11. How do you use a decision-making model to make a decision about an environmental issue? 12. What values are important in making decisions about the environment? 13. What is Environmental Health? 14. What are Epidemiology and Toxicology? 15. What is Risk Assessment and how is it used in human health?

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32. Understand how to evaluate risk to assess how to handle various natural and human-made hazards and human health. 33. The health of humans and other organisms are affected by their interactions with each other and their environment and may be altered by human manipulation. 34. Recognize that in order to help maintain the health of an organism, the immune system works in nonspecific ways (e.g., skin, mucous, membranes) and specific ways (e.g., antibody-antigen interactions.) 35. Investigate how scientists use biotechnology to produce more nutritious food, more effective medicine, and new ways to mitigate pollution. 36. Investigate how drugs can affect neurotransmission. 37. Explain how antibiotics (e.g., penicillin, tetracycline) kill bacterial cells without harming human cells due to differences Between prokaryotic and eukaryotic cell structure. 38. Describe how environmental factors (e.g., UV light or the presence of carcinogens or pathogens) alter cellular functions. 39. Certain environmental issues are problems are of concern for historians, scientists, civic leaders, economists and doctors studying evidence from the past help us prevent future problems and make informed decisions that will better affect our future.	16. What are infectious diseases? 17. How can dosage and dose-response affect treatment of diseases? 18. Why are emerging diseases becoming a major human health and environmental issue? 19. What are teratogens, neurotoxins and carcinogens? 20. Why are Biomagnification and Bioaccumulation important to assess risk for human consumption of foods? 21. How can natural disasters affect individuals, communities and society, as well as the environment and human health?

Stage 2: Evidence of Learning

Performance Task 1: Have student list 20 possible biological or chemical hazards that they could be exposed to within their home, school, community. Can be assigned as in-class, homework assignment. Submitted on paper or typed. One page. This should generate a discussion of common choices. Scoring Rubric Included

Performance Task 2: Student list 10 Social Hazards in school, home or community that are personal choice or others which cannot be controlled. This can be discussion as opposed to written or use both. Scoring Rubric Included

Performance Task 3: Map-it exercise on page 278. Supplement with current news stories of actual earthquakes or volcanos recorded in last 6 months in that area. Scoring Rubric Included

Supplemental Performance tasks:

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DVD/News media or current event Opinion Papers Chapter/Lesson Quiz
Other evidence of learning: Chapter quiz/test/ Teacher designed assessments. Vocabulary – Student-centered worksheet/puzzles. Central Case Studies – Student Discussion/Debate on ‘Big-Question.’ Chapter Worksheets: Key concepts, Flow Charts, Open-ended questions, Student Participation: Student originated questions and debate about lecture topics, chapter issues and current events from news.

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<table>
<tr><th colspan="2">Stage 3: Learning Plan</th></tr>
<tr><th colspan="2">Objectives</th></tr>
<tr><td>The Students will know:
• Risk Management.
• Hazards that affect human health.
• How toxicity can build-up or bio-accumulate in the food chains/web.
• What carcinogens, teratogens, allergens and neurotoxins are and their effects on people.
• That some health hazards come from poor lifestyle choices.
• Effect on environment.
• Natural disasters cause more than physical damage
• How diseases can be transmitted
• Mistreatment of the environment due to Anthropogenic reasons may be the cause of some emerging diseases.</td><td>The Students will be able to (TSWBAT):
• Identify the steps involved with solving issues, questions and problems using organized process of evidence-gathering, inquiry, observation and analysis and dealing with risk involved with human and environmental health.
• Explain how humans affect their environment by their use of natural resources.
• Understand and explain how chemical, biological, social and natural hazards can affect out lifestyle and human health, culture and ethics impact society and the environment.
• Interpret dosage-dose response tables..
• Increase their reading comprehension of scientific papers and news stories and develop personal opinion based upon evidence, inquiry and observations.
• Understand how government at every level works with key issues about the environment.
• Identify the several key man-made widely used chemicals and compounds that have short and long-term toxicity to humans.</td></tr>
</table>

<table>
<tr><th colspan="2">Learning Activities/Instructional Strategies</th></tr>
<tr><th>Lesson</th><th>Timeframe</th></tr>
<tr><td>UNIT 6 Environment and Human Health – Lesson 1 Overview
Key Terms: Environmental health, hazards, pathogens, epidemiology, toxicology, toxicity, dose-response relationship, dose, risk, risk assessment.
• Introduce the discussion about the ways human health can be affected by environmental causes/issues.. Discussion about the current issues about the environment, locally, national and world-wide.
• <u>Textbook Chapter 9 lesson 1 pages 254-260</u>
• Discussion on Essential Questions/Objectives and Four types of Hazards
• Lecture-PowerPoint (teacher generated or textbook supplied)
• Unit Vocabulary. (student worksheet or puzzle or crossword)
• Central Case/Discussion: <u>Rise and Fall-and Rise of DDT</u>.
• How human population has changed use of natural resources.
• Teacher choice chapter/lesson assessments.</td><td>2 day</td></tr>
<tr><td>UNIT 6 Environment and Human Health – Lesson 2 Biological and Social Hazards
Key Terms: Infectious diseases, emerging diseases
• Teacher-Lecture on what is and how infectious diseases and emerging diseases spread. (PowerPoint-teacher designed or textbook)
• <u>Textbook Chapter 9, lesson 2 pages 261-266</u></td><td>3 days</td></tr>
</table>

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• **DVD about Biological Hazards:** Select one from list below or choose your own. Students complete Questions associated with documentary for class discussion. Ebola: The Plague Fighters (Nova) The Virus Hunters (National Geographic) Contagion (Warner Bros.) • Student in-class, homework assignments. • Student worksheet assignments • LAB- on testing for viruses (requires 1-2 weeks for culturing and microscopes) or Quick Lab on page 263 or teacher designed lab to illustrate how viruses spread. • **Performance Task 1: Think/write and discuss** Student list 10 Social Hazards in school, home or community that are personal choice or others which cannot be controlled. This can be discussion as opposed to written or use both. • Teacher choice chapter/lesson assessments.	
UNIT 6 Environment and Human Health - Lesson 3 Toxic Substances **Key Terms:** Pollution, carcinogen, teratogen, neurotoxin, asbestos, radon, bioaccumulation, and Biomagnification. • PowerPoint Lecture Chapter 9 Lesson 3 Toxic Substances in the Environment. Pages 267-276 (teacher designed or textbook provided) • **Think/write and discuss: Performance Task 2: Think/write and discuss** Have student list 20 possible biological or chemical hazards that they could be exposed to within their home, school, community. Can be assigned as in-class, homework assignment. Submitted on paper or typed. One page. This should generate a discussion of common choices. • In-Class discussion on bioaccumulation of toxic substances in fish. http://www.nj.gov/dep/dsr/trends/pdfs/fishconcentrations.pdf http://www.nj.gov/dep/dsr/njmainfish.htm http://www.foodandwaterwatch.org/common-resources/fish/seafood/guide/ • Below is a YouTube Video link that can help you understand chemical toxicity in seafood and bioaccumulation/Biomagnification. https://www.youtube.com/watch?v=p6Jabn5rhtk • Assess student's skills and mastery of concepts and issues through use of open-ended questions and teacher-student debate and discussion. Assess written essay and presentation of student thoughts, comprehension of issue and writing skill.	**3 days**
UNIT 6 Environment and Human Health – Lesson 4 Natural Disasters **Key Terms:** Earthquake, landslide, volcano, tsunami, tornado, hurricane, thunderstorm, avalanche. • DVD Natural Disasters. Select from list below or choose your own DVD. Students complete Questions associated with documentary for class discussion. Witness: Disaster in Japan (National Geographic) Tsunami that Shook the World (WGBH Boston) Hurricane Katrina – A Storm that Drowned a City. (NOVA) Twister (Warner Bros) Last Days on Earth (ABC News)	**3 days**

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• PowerPoint Lecture Chapter 9 Lesson 4 Natural Disasters. Pages 277-289 (teacher designed or textbook provided) • **Performance Task 3**: Map-it exercise on page 278. Supplement with current news stories of actual earthquakes or volcanos recorded in last 6 months in that area. In-class or homework assignment. Relate to Chapter on Earth Structure-Ring of Fire, Plate Tectonics. • Student worksheets	
• Assess student's skills and mastery of concepts and issues through use of quiz and/or test using combination of multiple choice and open-ended questions, in-class discussions and hands-on assignments.	**1 day**

Individual Accommodations
• Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team. • Modified worksheets, quizzes and other assignments as required. • Provide enrichment assignments for early finishers. • Provide limited Extra Credit assignments. • Allow for additional time for different learning styles. • Differentiate instruction for varied learning styles. • Include technology into the classroom. • Allow for group interaction. • Encourage use 'flipped' classroom instruction by students. • Develop make-up assignments, quizzes and test as required. • ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature___________________________________
Date_____________________

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UNIT 7 Land Use, Resource Management, Soil and Food	**Number of Days: 22**
Content Area: Environmental Science	

Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them. Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, meteorology, botany, biology, chemistry and the social sciences.

Many of our objectives, lessons and essential questions will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world.

UNIT 7 Land Use and Soil will help the student understand how we use land and its natural resources, including soil characteristics formation and use. **Land use** is the human use of land. Land use involves the management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats such as farms arable fields, pastures, and managed woods. It also has been defined as "the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it" This lesson will also explore the rationale for preserving land for parks, preserves and public/private use. Including National Parks, National Preserves, Historic places and protected land.

This **UNIT** will cover textbook chapters:
Chapter 10 **- Land Use and Urbanization**
Chapter 11 **- Forestry and Resource Management**
Chapter 12 **- Soil and Agriculture**
Chapter 13 **- Mineral Resources & Mining**

Key Terms: land cover, land use, infrastructure, urban, rural, sprawl, smart growth, resource management, maximum sustainable yield, old-growth forest, clear-cutting, deforestation, prescribed burn, soil horizon, silt, sand, loam, clay, weathering, soil degradation, crop rotation, desertification, salinization, biological pest control, integrated pest control, pollinator, green revolution, GMO's seed bank, biotechnology.

Grade Level: 9-12

21st Century Themes

	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

21st Century Skills

	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

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Materials/Equipment needed:

- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators
- Pearson Textbook and on-line/printed workbook
- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- maps
- ACHS Media Center – Gale Databases, library collections
- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

- **DVD: Suggested DVD's (select one or parts from one as time appropriate…)**
- DVD: **Temple Grandin** (Livestock Mgmt., animal husbandry – HBO Films)
- DVD: **Fire Wars** (NOVA - WGBH Boston Video)
  DVD/Media **The Pinelands: Up Close and Natural** (Pinelands Preservation Alliance DVD)
- **DVD DIRT! The Movie** (docudrama films)
  Volume 12 Soil (The Geography Tutor**)**
- Your choices_______________________
- **NBC Learn** news stories videos about earth structure and atmospheric events**…**and more.
- **Chapter PowerPoint's**
- **Student Workbook Assignments – Chapters 10, 11, 12, 13**
- **Chapter and Lesson Assessments**
- **Chapter Quiz**

Suggested/Optional DVD's :
YouTube Videos of: Mexico City Urban Sprawl: https://www.youtube.com/watch?v=7IN0BG39BEA
Primary Models of Urban Growth: https://www.youtube.com/watch?v=EjMarOuFAps
https://www.youtube.com/watch?v=HyXg2aTEgOI
Effects of Land Use on Ecosystems: https://www.youtube.com/watch?v=dRVHm3jvsQo
Global land cover change from 8000 BP to -50 BP https://www.youtube.com/watch?v=gBTlIaf12-4
APES Lecture on Land Use https://www.youtube.com/watch?v=2WtzJEuZS-g
TEACHER Selected Choices:____________________________

Web-based sites: NJ Pinelands
NJ Pinelands Commission: http://www.state.nj.us/pinelands/
Pinelands Maps: http://www.nj.gov/pinelands/landuse/gis/maps/
Pinelands Preservation Alliance: http://www.pinelandsalliance.org/

Cross-Curricular References/Projects:

ART: Drawing and interpretation skills
Writing: Essay and science research papers
MATH/STEM: using computer generated systems (GIS) to monitor, develop and control land use.

Stage 1: Desired Results (Learning Targets)

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Standards (Include cross-curricular)

Science - NJ 2009 Core Curriculum Content Standards (NJCCCS)

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. (Grades: 9,10,11,12)
5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. (Grades: 9,10,11,12)
5.1.A Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. (Grades: 9,10,11,12)
5.1.A Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)
5.1.A Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. (Grades: 9,10,11,12)
5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. (Grades: 9,10,11,12)
5.1.B Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. (Grades: 9,10,11,12)
5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)
5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standards: **5.3** Life Science: Life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics. (Grades: 9,10,11,12)
5.3.C Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs. (Grades: 9,10,11,12)
5.3.C Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms. (Grades: 9,10,11,12)
5.3.C.5.3.12.C.1 Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem. (Grades: 9,10,11,12)
5.3.C Stability in an ecosystem can be disrupted by natural or human interactions. (Grades: 9,10,11,12)

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5.3.C.5.3.12.C.2 Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations. (Grades: 9,10,11,12)
5.10.5.10.12 B.2 Use scientific, economic, and other data to assess environmental risks and benefits associated with societal activity. (Grades: 9,10,11,12)
Science - NJ 2009 Core Curriculum Content Standards: **5.4** Earth Science:
5.4 Earth Systems Science: Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe. (Grades: 9,10,11,12)
5.4.C Properties of Earth Materials: Earth's composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.1 Model the interrelationships among the spheres in the Earth systems by creating a flow chart. (Grades: 9,10,11,12)
5.4.C The chemical and physical properties of the vertical structure of the atmosphere support life on Earth. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.2 Analyze the vertical structure of Earth's atmosphere, and account for the global, regional, and local variations of these characteristics and their impact on life. (Grades: 9,10,11,12)

Next Generation Science Standards (NGSS)

HS. Earth's Systems

HS. Human Sustainability

Students who demonstrate understanding can:
HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shale's), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [*Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.*]

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and

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livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

Earth Science – HSS-Earth Systems

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.[Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [*Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.*]

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

Other Cross-Curricular Standards

Writing techniques, essay and opinion papers, and grammar subjects. MLA/APA Citations

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Reading Comprehension How to read scientific articles and news stories to get relevant evidence and information from them
History/Social Studies

Enduring Understandings: (What Students will know)	**Essential Questions**
• How to analyze the spatial organization of places, and environments on earth's surface • How to apply earth and environmental science and geography to interpret the present and plan for the future. • People manage the Earth and its resources by preservation, conservation, appropriate utilization, and restoration. • The complexity and interaction of these ecosystems requires individual and collaborative efforts on a local, regional, national, and international scale. • Humans can alter the living and non-living factors within an ecosystem, thereby creating changes to the overall system. • Earth is made of materials including rocks, soil, water and air. • Rocks can be recognized and grouped/sorted by physical properties. Senses can be used to observe soil. • Soil is the basis for growing all plants on Earth.	• How do geospatial information technologies enable us to view and understand patterns in our environment? • How do we impact our ecosystem? • How do current building trends affect the local ecosystem? • What causes urban heat islands and to what extent do they occur in Atlantic City? New Jersey? • How can I use environmental and geographic data to better understand my environment? • How can I analyze and interpret environmental and geographic data to plan for the future? • How can we use our senses to sort things from the earth? • How are rocks alike and different? • How are soils alike and different? • How can I describe a rock? • How can I describe soil? • Why do we set aside land for National Parks? • How do National Parks and Preserves differ?

Stage 2: Evidence of Learning

Performance Task 1: **Documentary-NJ Pinelands, Preserves & Protected Areas**
Essay objectives:
1. Research and learn about the Pinelands and its relevance to the State of NJ and United States.
2. Practice Internet research.
3. Develop reading comprehension,
4. Essay/research paper writing skills

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Directions: write a 600-1000 word essay about the NJ Pinelands. The research can be found at these web sites: http://www.state.nj.us/pinelands/ and http://www.pinelandsalliance.org/ as well as others with additional research. Page one should be a summary of key facts and history. Page two should include a discussion on the importance of the reserve, reasons why it was made a reserve and what are some of the complications involved with managing it and how the people who live there deal with those restrictions, laws and problems. There are several issues; the choices are up to your personal interest. Scoring Rubric Included DVD/Media: The Pinelands: 'Up Close and Natural' (Pinelands Preservation Alliance DVD) **Performance Task 2: Mini-lab - illustrate Soil Horizons.** **Supplemental Performance Task 3:** Minerals and their uses in our environment Questions/Discussions based upon independent or teacher-guided research. **Supplemental Performance Task 3:** Research, plan and Illustrate a town or city you'd like to live in. Using all the information in chapter 10.
Other evidence of learning: Chapter quiz Vocabulary – Student-centered worksheet/puzzles. Chapter Worksheets: Key concepts, Flow Charts, Open-ended questions, Student Participation: Student originated questions and debate about lecture topics, chapter issues and current news stories.

Stage 3: Learning Plan	
Objectives	
The Students will know: • Identify the principles, goals, and approaches of resource management • Summarize the ecological roles and economic contributions of forests, and outline the history and scale of forest loss • Explain the fundamentals of forest management, and describe the major methods of harvesting timber • Analyze the scale and impacts of agricultural land use • Identify major federal land management agencies and the lands they manage • Recognize types of parks and reserves, and evaluate issues involved in their design • Rocks can be changed naturally by water or weather. • There are different kinds of rocks often varying by location. • Soil has observable differences such as color and texture. • Soils and land need to be managed for sustainable yields.	**The Students will be able to (TSWBAT):** • Describe how advances in technology can increase the carrying capacity of an ecosystem (i.e., advances in agricultural technology have led to increases in crop yields per acre). • Examine and describe how social and biological factors influence the exponential growth of the human population (e.g., economic, cultural, age at reproduction, fertility rate, birth/death rate, and environmental factors). • Examine and describe how the exponential growth of the human population has affected the consumption of renewable and non-renewable resources. • Evaluate decisions about the use of resources in one country and how these decisions can impact the diversity and stability of ecosystems globally. • Analyze ways in which human activity (i.e., producing food, transporting materials, generating energy, disposing of waste, obtaining fresh water, or extracting natural resources) can affect ecosystems and the organisms within. • Research and discuss ways in which humans use technology to reduce the negative impact of human activity on the environment.

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Learning Activities/Instructional Strategies	
Lesson	**Timeframe**
UNIT 7 Land Use & Soil Chapter 10 **Key Terms:** Land cover, land use, urban areas, rural areas, urbanization, infrastructure, heat islands, sprawl, city planning, geographic information systems (GIS), zoning, urban growth boundary (UBG), smart growth, greenway, ecological restoration. • Central Case: *Growing Pains in Portland Oregon*. How can we balance our needs for housing with the needs of the environment? • Introduce the definition and importance of the Land Use. • Chapter 10 Urbanization, pages 290-319 • Discussion on Essential Questions/Objectives • Teacher generated or textbook Lecture-PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • DVD- (Teacher Choice or from recommended list) • NBC Learn or YouTube selections on Land • **Supplemental Performance Task 3:** Research, plan and Illustrate a town or city you'd like to live in. Using all the information in chapter 10.	**3 days**
UNIT 7 Land Use & Soil Chapter 11 **Key Terms:** Resource management, maximum sustainable yield (MSY) ecosystem-based management, adaptive management, even-aged, uneven aged, clear-cutting, deforestation, old-growth forest, multiple use, monoculture, prescribed burn, salvage logging, sustainable forestry certification. • Central Case: *Battling over Clayoquot's Big Trees*. Big Question: "How can we use Earth's resources sustainably?" • Introduce the definition and importance of managing our forests. • Chapter 11 Resource Management, pages 322-349 • Discussion on Essential Questions/Objectives • Teacher generated or textbook Lecture-PowerPoint • Quick lab page: 334 • Real Date exercise on page 332. • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • DVD- (Teacher Choice or from recommended list) • NBC Learn or YouTube selections on forests, trees and deforestation, NJ Pinelands, National Park and Preserves. • **Performance Task 1**: **Writing Assignment-NJ Pinelands, Preserves & Protected Areas**	**3 days**
UNIT 7 Land Use & Soil Chapter 12 SOIL/Agriculture **Key Terms:** Soil, parent material, bedrock, weathering, soil horizons, soil profile, clay, silt, loam, soil degradation, crop rotation, cover crop, over-grazing desertification, irrigation, salinization, pesticide, traditional agriculture, industrial agriculture, yield, green revolution, integrated pest management (IPM), biological pest control, pollinator, • Central Case: *Possible Transgenic Maize in Oaxaca Mexico*. Big Question: "How can we balance our growing demand for food with our needs to protect the environment?"	**4 days**

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• Introduce the definition and importance of managing our forests. • Chapter 12 Soil and Agriculture, pages 350-372 • Discussion on Essential Questions/Objectives • Teacher generated or textbook Lecture-PowerPoint • Discuss Figure 5 page 356 • Go Outside (Optional) page: 356 • Map-it exercise on page 366 Origins of Agriculture. • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • DVD- (Teacher Choice or from recommended list) • NBC Learn or YouTube selections on farming or agriculture, pesticides, pest control pollution • **Performance Task 2: Mini-lab - illustrate Soil Horizons. Page 355**	
UNIT 7 Land Use & Soil Chapter 13 Minerals **Key Terms:** minerals, rock and rock cycle • Central Case: *Mining for…Cell Phones?* Big Question: "At what point do the costs of mining outweigh the benefits?" • Introduce the definition and importance of minerals. • Chapter 13 Mineral Resources and Mining, pages 390-417 • Discussion on Essential Questions/Objectives • Teacher generated or textbook Lecture-PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • **Supplemental Performance Task 3:** Minerals and their uses in our environment. Questions/Discussions based upon independent or teacher-guided research.	**2 days**
UNIT 7 Land Use & Soil • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	
UNIT 7 Food **Key Terms:** arable land, food security, malnutrition, genetically modified foods (GMO's) biotechnology, feedlot, aquaculture, sustainable agriculture. • Introduce the definition and importance of the Food, Food Production, food labeling, Nutrition, Food Security. • Discussion on Essential Questions/Objectives • Lecture-PowerPoint (Teacher generated or textbook) • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheet • DVD - (Teacher Choice) • NBC Learn or YouTube selections on Food & Food Security, Labeling. • **Performance Task 2:** Mini-lab Understanding Food Labeling. Student (individual or group) project. Use internet to find labels and review ingredients, nutrition information and determine if the ingredients are possibly harmful to humans or health/ • **Supplemental (optional) Performance Task 2:** DVD Questions/Discussions	
UNIT 7 Food • Assess students skills and mastery of concepts and issues through use of : class discussion/debate, open-ended questions, multiple choice and essay	

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Individual Accommodations
• Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team. • Modified worksheets, quizzes and other assignments as required. • Provide enrichment assignments for early finishers. • Provide limited Extra Credit assignments. • Allow for additional time for different learning styles. • Differentiate instruction for varied learning styles. • Include technology into the classroom. • Allow for group interaction. • Encourage use 'flipped' classroom instruction by students. • Develop make-up assignments, quizzes and test as required. • ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature_______________________________________
Date______________________

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UNIT 8 Water Resources	Number of Days: 20
Content Area: Environmental Science	

Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them. Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, meteorology, botany, biology, chemistry and the social sciences.

Many of our objectives, lessons and essential questions will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world.

UNIT 8 Water Resources will help the student understand how we use the fresh and salt water on the planet. "Water, water everywhere, nor any drop to drink" from the poem *The Rime of the Ancient Mariner*, aptly describes our situation. Our planet is covered in water, found frozen in ice and comes from the sky as rain/snow or sleet. Yet do we have enough to sustain human life? Human-centered activities causing water over-use, shortages and pollution have endangered our supply. This unit examines the amounts and locations of our water supply as well as how we typically utilize water and how we misuse it and some of the ways we can conserve and clean-up existing water supplies.

Grade Level: 9-12

21st Century Themes

	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

21st Century Skills

	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

Materials/Equipment needed:

- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators
- Pearson Textbook and on-line/printed workbook
- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- maps
- ACHS Media Center – Gale Databases, library collections

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- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

- **DVD: Suggested DVD's (select one or parts from one as time appropriate…)**
- **DVD: The Hydrological Cycle** (Earth Science Video Library)
- **DVD: Understanding Oceans** (Discovery Education)
- **DVD: Oceans** (Disney Nature) or your choice of Ocean Documentary
- **DVD: Gimmie Green** (docudrama films) About the over use of water on lawns.
- **Supplemental Choice DVD: The Simpson Movie** (20th CenturyFOX) Water Pollution Topic.
- **Supplemental Choice DVD: Biology of Seashores** (BioMedia Associates)
- **Supplemental Choice DVD: Drain the Ocean** (National Geographic)
- **Supplemental Choice DVD: The End of the Line** (Docudrama) About Over-fishing
- **Supplemental Choice DVD: The Cove** (Lionsgate) About Killing of Dolphins
- Your choices______________________
- **NBC Learn** news stories videos about water pollution, groundwater, aquifers and atmospheric events…and more.
- **Chapter or teacher developed PowerPoint's**
- **Student Workbook Assignments – Chapter 14**
- **Chapter and Lesson Assessments**
- **Chapter Quiz**

Suggested/Optional DVD's :
YouTube and NBC Learn Videos of: Water Resources.
Water Cycle National Science Foundation: https://www.youtube.com/watch?v=al-do-HGuIk
Ogallala Aquifer https://www.youtube.com/watch?v=XXFsS94HF08
What is Groundwater: https://www.youtube.com/watch?v=oNWAerr_xEE
What is an Estuary? https://www.youtube.com/watch?v=XLumSN4G5P4
Toxic Waters in Harbors: https://www.youtube.com/watch?v=rreBKDko6OY
Estuaries: https://www.youtube.com/watch?v=h01JBiZt6rg
Bill Nye The Science Guy - Pollution Solutions: https://www.youtube.com/watch?v=vVmmpGeR6nk
EPA Clean Water Act: https://www.youtube.com/watch?v=ow-n8zZuDYc
ARAL SEA: https://www.youtube.com/watch?v=oNDjL_q7kHU
Aral Sea: https://www.youtube.com/watch?v=dp_mlKJiwxg
Water Pollutants: https://www.youtube.com/watch?v=ACgv19b-n5E
Why are we losing Groundwater: https://www.youtube.com/watch?v=2cFOYvtJejw
TEACHER Selected Choices:__________________________

Web-based sites: Water Resources
USGS Water Cycle http://water.usgs.gov/edu/watercyclefreshstorage.html:
NIEHS: http://www.niehs.nih.gov/health/topics/exposure/water-poll/
Encyclopedia of the Earth: Water Pollution http://www.eoearth.org/view/article/156920/
Encyclopedia of the Earth: Oil Spills http://www.eoearth.org/view/article/158443/

NRDC: http://www.nrdc.org/water/
Water Conservation: http://www.conservation.org/what/Pages/Fresh-water.aspx
EPA Effects of Nutrient Pollution: http://www2.epa.gov/nutrientpollution/effects-human-health
EPA Oil Spills: http://www.epa.gov/osweroe1/content/learning/effects.htm

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National Geographic Gulf Oil Spill: http://news.nationalgeographic.com/news/gulf-oil-spill-news/#.U9EjqEC9aK8
Time Magazine Timeline of 2010 Gulf Oil Spill:
http://content.time.com/time/interactive/0,31813,2006455,00.html
2010 Gulf Oil Spill: http://ocean.si.edu/gulf-oil-spill

Cross-Curricular References/Projects:

ART: Drawing and interpretation skills
Writing: Essay and science research papers
MATH/STEM: using computer generated systems (GIS) to monitor, develop and control land use.

Stage 1: Desired Results (Learning Targets)

Standards (Include cross-curricular)

Science - NJ 2009 Core Curriculum Content Standards (NJCCCS)

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. (Grades: 9,10,11,12)
5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. (Grades: 9,10,11,12)
5.1.A Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. (Grades: 9,10,11,12)
5.1.A Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)
5.1.A Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. (Grades: 9,10,11,12)

5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. (Grades: 9,10,11,12)
5.1.B Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. (Grades: 9,10,11,12)
5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)

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5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standards: **5.3** Life Science: Life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics. (Grades: 9,10,11,12)
5.3.C Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs. (Grades: 9,10,11,12)
5.3.C Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms. (Grades: 9,10,11,12)
5.3.C.5.3.12.C.1 Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem. (Grades: 9,10,11,12)
5.3.C Stability in an ecosystem can be disrupted by natural or human interactions. (Grades: 9,10,11,12)
5.3.C.5.3.12.C.2 Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations. (Grades: 9,10,11,12)
5.10.5.10.12 B.2 Use scientific, economic, and other data to assess environmental risks and benefits associated with societal activity. (Grades: 9,10,11,12)
Science - NJ 2009 Core Curriculum Content Standards: **5.4** Earth Science:
5.4 Earth Systems Science: Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe. (Grades: 9,10,11,12)
5.4.C Properties of Earth Materials: Earth's composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.1 Model the interrelationships among the spheres in the Earth systems by creating a flow chart. (Grades: 9,10,11,12)
5.4.C The chemical and physical properties of the vertical structure of the atmosphere support life on Earth. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.2 Analyze the vertical structure of Earth's atmosphere, and account for the global, regional, and local variations of these characteristics and their impact on life. (Grades: 9,10,11,12)

Next Generation Science Standards (NGSS)

HS. Earth's Systems

HS. Human Sustainability

HS. Weather & Climate

HS. Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:
HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement:

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Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]

HS-LS2-2. **Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]

HS-LS2-6. **Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS2-8. **Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.**[Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.***[Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

HS-ESS2-4. **Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.*]

HS-ESS3-5. **Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.*]

HS-ESS3-1. **Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as

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tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [*Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.*]

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.[Clarification Statement: Emphasis is on the dynamic causes, effects,

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and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [*Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.*]

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

Other Cross-Curricular Standards

Writing techniques, essay and opinion papers, and grammar subjects. MLA/APA Citations
Reading Comprehension How to read scientific articles and news stories to get relevant evidence and information from them
History/Social Studies

Enduring Understandings: (What Students will know)	**Essential Questions**
• Why are we running out of water? • Water is an essential limited natural resource on Earth. • A balance must exist in the environment that should allow for clean air, freshwater, and soil capable of producing food. • All people are responsible for maintaining the balance of places, and environments on earth's surface • Wetlands must be protected to maintain clean water. • Each citizen can take action to maintain a clean water supply. • How to apply earth and environmental science and geography to interpret the present and plan for the future.	• What are the main water sources on Earth? • How does the Sun's energy influence water on Earth? • What is a watershed? • What are point and nonpoint sources of pollution? • What are the various types of water pollution? • What is the impact of water pollution on people and on the environment? • Why is groundwater pollution hard to clean? • What are the effects of polluted oceans on humans? • How can you describe the water cycle? • Why is water conservation necessary? • How can you conserve water? • How does water pollution occur? • What are the effects of Pollution on Humans, all life and our environment? • How do we impact our freshwater and salt water ecosystems?

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• People manage the Earth and its resources by preservation, conservation, appropriate utilization, and restoration.	• How can I use environmental and geographic data to better understand my environment?

Stage 2: Evidence of Learning
Performance Task 1: PowerPoint Presentation that will discuss and describe the types of freshwater and saltwater ecosystems around the Atlantic City or New Jersey locales and their impact on the environment and how humans affect them. Choose one of these ecosystems: **Salt Marsh** (where the high school is located) **Barrier Island** (Atlantic City, Ventnor, Margate, Brigantine are on these) **Estuary**, (the water in-between the barrier island and mainland) and the **Ocean.** **Performance Task 2:** You are required to find two (3) newspaper or Internet articles that deal with some type Water pollution in Atlantic City, or somewhere in the State of New Jersey. Read the articles, write a 1 page summary of what each is about and your opinion of them and be prepared to discuss them on Tuesday & Wednesday in class. Each student will have the opportunity to stand up in class and discuss their news stories. Scoring Rubric Included **Performance Task 2: Illustrate the Water Cycle using internet or textbook.** Scoring Rubric Included. **Performance Task 3:** PowerPoint or Essay on the effects of nitrogen pollution in Barnegat or Chesapeake Bays, creating "Dead Zones". Internet research using news stories, central case on dead zones, eutrophication, nitrate pollution. **Teacher-defined conditions**. Scoring Rubric Required. **Supplemental Performance Task 1: Ogallala Aquifer** **Supplemental Performance Task 2: Aral Sea**
Other evidence of learning: Chapter quiz Vocabulary – Student-centered worksheet/puzzles. Chapter Worksheets: Key concepts, Flow Charts, Open-ended questions, Student Participation: Student originated questions and debate about lecture topics, chapter issues and current news stories.

Stage 3: Learning Plan	
Objectives	
The Students will know: • The water cycle is the movement of water from the ground to the air and back to the ground by evaporation, condensation, and precipitation.	**The Students will be able to (TSWBAT):** • Identify the sun as the origin of energy that drives the water cycle.

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• The energy that drives this cycle comes from the sun. • During the water cycle, liquid water is heated and changed to a gas (water vapor). This process is called evaporation. The gas (water vapor) is cooled and changed back to a liquid. This process is called condensation. Water as a liquid or a solid falls to the ground as precipitation. • Our water supply on Earth is limited. Pollution reduces the amount of usable water; therefore, the supply should be carefully conserved. • Water is a simple compound essential for life on Earth. • Living cells are mostly water. In each cell, the chemicals necessary for life are dissolved in water	• Describe the processes of evaporation, condensation, and precipitation as they relate to the water cycle. • Construct and interpret a model of the water cycle. • Identify the different ways that organisms get water from the environment. • Identify major water sources for a community, including rivers, reservoirs, and wells. • Describe the major water sources for the local community. • Explain methods of water conservation in the home and school. • Identify and communicate the importance of water to people and to other living organisms. • Analyze possible sources of water pollution in their neighborhoods, at school, and in the local community. This includes runoff from over-fertilized lawns and fields, oil from parking lots, eroding soil, and animal waste. • Research and discuss ways in which humans use technology to reduce the negative impact of human activity on the environment.

Learning Activities/Instructional Strategies	
Lesson	**Timeframe**
UNIT 8 Water Resources – Where is our Water? **Key Terms: Fresh water, surface water, runoff, watershed, groundwater. Permeable, impermeable, aquifer, water table. Recharge zone, well.** • Introduce the definition and importance of the Earth's Water Supply. • Textbook pages 418-433 • Discussion on Essential Questions/Objectives • Lecture or teacher generated or textbook PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheet • LAB: build a groundwater example like on page 424. • Student Activity Idea: Find a watershed in South Jersey and map its start/end. • Map-it exercise on page 422 • **LAB-Where is our Freshwater located?** Visual of %of freshwater on the planet using various size beakers of colored water in proper proportions to figure 1 on page 420 and discussion about how and where that water is located? • **Performance Task 1: PowerPoint Presentation** that will discuss and describe the types of freshwater and saltwater ecosystems around the Atlantic City or New Jersey • **Performance Task 2: Illustrate the Water Cycle using internet or textbook** • DVD-Earth Systems (Teacher Choice) • NBC Learn or YouTube selections on Water, water pollution, pollutants, freshwater, aquifers, groundwater.	**5 days**

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• Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	
UNIT 8 Water Resources – How we use Water. **Key Terms: dams, reservoirs, desalinization, salinization.** • Textbook Pages 426-434 • Discussion on Essential Questions/Objectives • Lecture and/or teacher generated or textbook PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheet • Real Data Exercise on page 431 • DVD-Water Uses (Teacher Choice) • NBC Learn or YouTube selections on Water, water pollution, pollutants, freshwater, aquifers, groundwater Student (individual or group) project. Illustrate and labeling the earth Spheres and their different sub-layers and importance to Humans • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**2 days**
UNIT 8 Water Resources – Water Pollution **Key Terms: point source pollution, non-point source pollution, cultural eutrophication, waste water, algal blooms, pathogens, red tide, septic system** • Textbook Pages 435-445 • Discussion on Essential Questions/Objectives • Lecture and/or teacher generated or textbook PowerPoint • Discuss the types of water pollutants. • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • LAB: Oil Spill Remediation • LAB: Quick Lab on Cultural Eutrophication on textbook Page 437 • Real Data Exercise on page 431 • DVD-Water Uses (Teacher Choice) • **Performance Task 3:** PowerPoint or Essay on the effects of nitrogen pollution in Barnegat or Chesapeake Bays, creating "Dead Zones". • NBC Learn or YouTube selections on Water, water pollution, pollutants, freshwater, aquifers, groundwater Student (individual or group) project. Illustrate and labeling the earth Spheres and their different sub-layers and importance to Humans • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**5 days**
UNIT 8 Water Resources • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**1 Day**

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Individual Accommodations
• Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team. • Modified worksheets, quizzes and other assignments as required. • Provide enrichment assignments for early finishers. • Provide limited Extra Credit assignments. • Allow for additional time for different learning styles. • Differentiate instruction for varied learning styles. • Include technology into the classroom. • Allow for group interaction. • Encourage use 'flipped' classroom instruction by students. • Develop make-up assignments, quizzes and test as required. • ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature______________________________________
Date______________________

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UNIT 9 AIR	Number of Days: 12

Content Area: Environmental Science

Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them. Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, meteorology, botany, biology, chemistry and the social sciences.

Many of our objectives, lessons and essential questions will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world.

UNIT 9 Air & Atmosphere: The **atmosphere of Earth** is a layer of gases surrounding the planet Earth that is retained by Earth's gravity. The atmosphere protects life on Earth by absorbing ultraviolet solar radiation, warming the surface through heat retention (greenhouse effect), and reducing temperature extremes between day and night (the diurnal temperature variations). The common name given to the atmospheric gases used in breathing and photosynthesis is **air**. By volume, dry air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide, and small amounts of other gases. Air also contains a variable amount of water vapor, on average around 1%. Although air content and atmospheric pressure vary at different layers, air suitable for the survival of terrestrial plants and terrestrial animals currently is only known to be found in Earth's troposphere and artificial atmospheres. The atmosphere has a mass of about 5.15×10^{18} kg, three quarters of which is within about 11 km (6.8 mi; 36,000 ft.) of the surface. The atmosphere becomes thinner and thinner with increasing altitude, with no definite boundary between the atmosphere and outer space. The Kármán line, at 100 km (62 mi), or 1.57% of Earth's radius, is often used as the border between the atmosphere and outer space. Atmospheric effects become noticeable during atmospheric reentry of spacecraft at an altitude of around 120 km (75 mi). Several layers can be distinguished in the atmosphere, based on characteristics such as temperature and composition. The study of Earth's atmosphere and its processes is called atmospheric science or **aerology**. The study of Weather is called **Meteorology** and the study of Earth's Climate is called **Climatology**.

Grade Level: 9-12

21st Century Themes

	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

21st Century Skills

	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

Materials/Equipment needed:

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- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators
- Pearson Textbook and on-line/printed workbook
- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- maps
- ACHS Media Center – Gale Databases, library collections
- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

- **DVD: Suggested DVD's (select one or parts from one as time appropriate…)**
- **DVD: Weather and Climate** (the Geography Tudor)
- **DVD: Core: Meteorology – Atmosphere** (ww.ambrosevideo.com)
- **DVD: The Greenhouse Effect** (Allied Video Corporation))
- **DVD: Clouds and what they mean** (Power Media Plus)
- **DVD: Air Pollution, Acid rain and Smog**. (Educational Video Network)
- **The Inconvenient Truth** (Climate Change)
- **Six Degrees could change the world.** (National Geographic)
- Your choices_______________________
- **NBC Learn** news stories videos about air pollution, ozone hole, acid rain and more….
- **Chapter or teacher developed PowerPoint's**
- **Student Workbook Assignments – Chapter 14**
- **Chapter and Lesson Assessments**
- **Chapter Quiz**
- **Suggested/Optional DVD's** :

YouTube and NBC Learn Videos SEARCH: Ozone, Ozone health effects, acid rain, air pollutants, air pollution.

Air Pollutions kills 6 million people/year: https://www.youtube.com/watch?v=oOk5G5vd2lw

Common Air Pollutants and their Sources: https://www.youtube.com/watch?v=UtdKRvWC1yQ

Ozone in the South Pole: https://www.youtube.com/watch?v=k4Ug-NWat04

Web-based sites: Air Pollution and Atmosphere

Water Cycle National Science Foundation: https://www.youtube.com/watch?v=al-do-HGuIk

National Geographic Air Pollution: http://environment.nationalgeographic.com/environment/global-warming/pollution-overview/

NRDC: http://www.nrdc.org/air/

Encyclopedia of the Earth: Weather & Climate: http://www.eoearth.org/topics/view/51cbfc79f702fc2ba8129f1c/

USA EPA Air pollutants: http://www.epa.gov/air/airpollutants.html

USA EPA Air Pollution: http://www.epa.gov/airquality/urbanair/

WHO Air Pollution: http://www.who.int/topics/air_pollution/en/

Ozone Hole: http://ozonewatch.gsfc.nasa.gov/

NIEHS: http://www.niehs.nih.gov/health/topics/agents/ozone/

US EPA Ozone: http://www.epa.gov/ozone/

US EPA Ground level Ozone: http://www.epa.gov/groundlevelozone/

US EPA Acid Rain: http://www.epa.gov/acidrain/

USGS Acid rain: http://water.usgs.gov/edu/acidrain.html

National Atmospheric Deposition: http://nadp.sws.uiuc.edu/educ/acidrain.aspx

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NOAA Weather, Oceans and Atmosphere: http://www.noaa.gov/
TEACHER Selected Choices:__________________________

Cross-Curricular References/Projects:

ART: Drawing and interpretation skills
Writing: Essay and science research papers

Stage 1: Desired Results (Learning Targets)

Standards (Include cross-curricular)

Science - NJ 2009 Core Curriculum Content Standards (NJCCCS)

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. (Grades: 9,10,11,12)
5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. (Grades: 9,10,11,12)
5.1.A Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. (Grades: 9,10,11,12)
5.1.A Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)
5.1.A Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. (Grades: 9,10,11,12)
5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. (Grades: 9,10,11,12)
5.1.B Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. (Grades: 9,10,11,12)
5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)
5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)

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Science - NJ 2009 Core Curriculum Content Standards: **5.3** Life Science: Life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics. (Grades: 9,10,11,12)

5.3.C Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs. (Grades: 9,10,11,12)

5.3.C Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms. (Grades: 9,10,11,12)

5.3.C.5.3.12.C.1 Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem. (Grades: 9,10,11,12)

5.3.C Stability in an ecosystem can be disrupted by natural or human interactions. (Grades: 9,10,11,12)

5.3.C.5.3.12.C.2 Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations. (Grades: 9,10,11,12)

5.10.5.10.12 B.2 Use scientific, economic, and other data to assess environmental risks and benefits associated with societal activity. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standards: **5.4** Earth Science:

5.4 Earth Systems Science: Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe. (Grades: 9,10,11,12)

5.4.C Properties of Earth Materials: Earth's composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life. (Grades: 9,10,11,12)

5.4.C.5.4.12.C.1 Model the interrelationships among the spheres in the Earth systems by creating a flow chart. (Grades: 9,10,11,12)

5.4.C The chemical and physical properties of the vertical structure of the atmosphere support life on Earth. (Grades: 9,10,11,12)

5.4.C.5.4.12.C.2 Analyze the vertical structure of Earth's atmosphere, and account for the global, regional, and local variations of these characteristics and their impact on life. (Grades: 9,10,11,12)

5.4.F Climate and Weather: Earth's weather and climate systems are the result of complex interactions between land, ocean, ice, and atmosphere. (Grades: 9,10,11,12)

5.4.F Global climate differences result from the uneven heating of Earth's surface by the Sun. Seasonal climate variations are due to the tilt of Earth's axis with respect to the plane of Earth's nearly circular orbit around the Sun. (Grades: 9,10,11,12)

5.4.F.5.4.12.F.1 Explain that it is warmer in summer and colder in winter for people in New Jersey because the intensity of sunlight is greater and the days are longer in summer than in winter. Connect these seasonal changes in sunlight to the tilt of Earth's axis with respect to the plane of its orbit around the Sun. (Grades: 9,10,11,12)

5.4.F Climate is determined by energy transfer from the Sun at and near Earth's surface. This energy transfer is influenced by dynamic processes, such as cloud cover and Earth's rotation, as well as static conditions, such as proximity to mountain ranges and the ocean. Human activities, such as the burning of fossil fuels, also affect the global climate. (Grades: 9,10,11,12)

5.4.F.5.4.12.F.2 Explain how the climate in regions throughout the world is affected by seasonal weather patterns, as well as other factors, such as the addition of greenhouse gases to the atmosphere and proximity to mountain ranges and to the ocean. (Grades: 9,10,11,12)

5.4.F Earth's radiation budget varies globally, but is balanced. Earth's hydrologic cycle is complex and varies globally, regionally, and locally. (Grades: 9,10,11,12)

5.4.F.5.4.12.F.3 Explain variations in the global energy budget and hydrologic cycle at the local, regional, and global scales. (Grades: 9,10,11,12)

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Next Generation Science Standards (NGSS)

HS. Interdependent Relationships in Ecosystems

HS. Weather & Climate

HS. Human Sustainability

HS Earth Science Earth Systems

Students who demonstrate understanding can:

HS-LS2-1. **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]

HS-LS2-2. **Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]

HS-LS2-6. **Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS2-8. **Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.**[Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.***[Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

HS-ESS2-4. **Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary:*

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Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.*]

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [*Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.*]

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geo-engineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

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HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.[Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [*Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.*]

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

Other Cross-Curricular Standards
Writing techniques, essay and opinion papers, and grammar subjects. MLA/APA Citations
Reading Comprehension How to read scientific articles and news stories to get relevant evidence and information from them

Enduring Understandings: (What Students will know)	**Essential Questions**
• The Sun is the major source of energy for the Earth. • The interaction of oceanic and atmospheric processes controls weather and climate by dominating	• How does our atmosphere make life possible on Earth? • How does photosynthesis and respiration balance carbon dioxide in the atmosphere? • What is the structure and properties of the atmosphere? • What causes the seasons?

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the Earth's energy, water, and carbon system. • The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat. • Changes in the ocean-atmosphere system can result in changes to the climate that in turn, cause further changes to the ocean and atmosphere. These interactions have dramatic physical, chemical, biological, economic, and social consequences • Weather and climate are the result of the interactions among Earth's water, its atmosphere and the Sun's heating of Earth's surface. • Earth has seasons because of its tilt and its revolution around the Sun. • Sunlight reaching the Earth can heat the land, ocean, and atmosphere. Some of that sunlight is reflected back to space by the surface, clouds, or ice. Much of the sunlight that reaches Earth is absorbed and warms the planet. • When Earth emits the same amount of energy as it absorbs, its energy budget is in balance, and its average temperature remains stable. Climate varies over space and time through both natural and man-made processes.	• Why is the earth and its atmosphere like a greenhouse? • How is weather different from Climate? • Explain how weather forms. • What causes urban heat islands and to what extent do they occur in Atlantic City? New Jersey? • Climate is determined by the long-term pattern of temperature and precipitation averages and extremes at a location. Climate descriptions can refer to areas that are local, regional, or global in extent. Climate can be described for different time intervals, such as decades, years, seasons, months, or specific dates of the year. • Climate is not the same thing as weather. Weather is the minute-by-minute variable condition of the atmosphere on a local scale. • Climate is a conceptual description of an area's average weather conditions and the extent to which those conditions vary over long time intervals • How do changes in one part of the Earth system affect other parts of the system? • Name the primary air pollutants. • Discuss the causes of acid rain. • How does understanding the properties of Earth materials and the physical laws that govern their behavior lead to prediction of Earth events?

Stage 2: Evidence of Learning

Performance Task 1: Mini-lab – Illustrate or PowerPoint the layers of the Atmosphere and include content about what happens in each layer and why they interact**.** Scoring Rubric Included
Performance Task 2: Illustrate or PowerPoint the different types of weather fronts**.**
Performance Task 3: Find 2 news stories from the internet or newspapers that are about: Ozone, acid rain, smog and particulate matter for discussion in-class. Provide a two paragraph summary of each article.

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Performance Task 4: Find 2-3 news stories from the internet or newspapers that are about: Climate Change and Global Warming, ENSO, Polar melting or Sea Rise. Provide a two paragraph summary of each article. Scoring Rubric Included **Supplemental Performance Task 1:** NAME and EXPLAIN three ways the atmosphere interacts with the oceans.
Other evidence of learning: Chapter quiz Vocabulary – Student-centered worksheet/puzzles. Chapter Worksheets: Key concepts, Flow Charts, Open-ended questions, Student Participation: Student originated questions and debate about lecture topics, chapter issues and current news stories.

Stage 3: Learning Plan	
Objectives	
The Students will know: • Seasonal changes on Earth Causes, Animal migrations • Angle of insolation and differential heating • Heat capacity and the role of the ocean in moderating Earth's climate. • Oceans and atmosphere connection • Ocean's influence on weather and climate • Coriolis Effect • Hurricane and storm formation • Ocean acidification • Acid precipitation. • Ozone Types and its potential depletion	**The Students will be able to (TSWBAT):** • Explain how the atmosphere makes life possible on Earth. • Explain heat transfer and the interaction of air masses in the troposphere. • Describe how the atmosphere is structured in layers. • Explain what causes the seasons. • Explain why the Earth and its atmosphere are like a greenhouse • Illustrate the Earth's tilt and how the angle of isolation relates to the differential heating the Earth's surface. • Explain the concept of heat capacity and the role of the ocean in moderating Earth's Climate and weather. • Relate changes in sea surface temperatures (SST) to changes in animal movements. • Explain how energy and water are transferred from the ocean to the atmosphere through the formation of air masses and tropical weather systems • Create a model that demonstrates the Coriolis Effect. • Describe how air masses, water cycle, air pressure, and wind contribute to hurricane formation. • Discuss how ocean acidification affects shell producing organisms. • Communicate anthropogenic impacts on coral reef ecosystems by acidification.

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Learning Activities/Instructional Strategies	
Lesson	**Timeframe**
UNIT 9 AIR - Earth's Atmosphere **Key Terms:** Atmosphere, relative humidity, air pressure, troposphere, stratosphere, ozone layer, mesosphere, thermosphere, radiation, conduction, convection, air masses, Coriolis Effect, weather fronts. • Textbook Pages 450-460 • Central Case: Charging towards cleaner air in London" • Discussion on Essential Questions/Objectives • Explain the Coriolis Effect and how it influence weather and ocean currents. • Lecture and/or teacher generated or textbook PowerPoint • Discuss the types of weather fronts and how they form. • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • LAB: Quick Lab on How does *hot water move* on textbook Page 459 • Real Data Exercise on page 431 • DVD-Water Uses (Teacher Choice) • **Performance Task 1: Mini-lab –** Illustrate or PowerPoint the layers of the Atmosphere and include content about what happens in each layer and why they interact**.** Scoring Rubric Included • NBC Learn or YouTube selections on atmosphere, weather and ocean currents. • **Performance Task 2**: Illustrate or PowerPoint the different types of weather fronts**.** • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**3 days**
UNIT 9 AIR - Pollution of the Atmosphere **Key Terms:** air pollution, primary air pollutants, secondary air pollutants, smog, ozone, temperature inversion, acid precipitation**.** • Textbook Pages 461- 468 • Discussion on Essential Questions/Objectives • Discuss and compare the Primary and secondary air pollutants from figure 12 on page 463.Discuss the possible human health effects of each. • Lecture and/or teacher generated or textbook PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • DVD-Water Uses (Teacher Choice) • **Performance Task 1: Mini-lab –** Illustrate or PowerPoint the layers of the Atmosphere and include content about what happens in each layer and why they interact**.** Scoring Rubric Included • NBC Learn or YouTube selections on atmosphere, weather and ocean currents. • **Performance Task 2**: Illustrate or PowerPoint the different types of weather fronts**.** • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**3 days**

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• Student (individual or group) project.	
UNIT 9 AIR – Controlling Air Pollution **Key Terms:** Clean Air Act, catalytic converter, scrubber, ozone hole, Montreal Protocol, chlorofluorocarbons (CFC's) • Textbook Pages 469-480 • Discussion on Essential Questions/Objectives • Lecture and/or teacher generated or textbook PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • LAB: Simulate Acid Rain. Lecture on pH and scale. • **Go Outside** and test for Acid Rain, Ozone and UV rays. (requires ozone testing kits and UV beads) • Real Data Exercise on page 471 • **Performance Task 3:** Find 2 news stories from the internet or newspapers that are about: Ozone, acid rain, smog and particulate matter for discussion in-class. Provide a two paragraph summary of each article. Scoring Rubric Included • NBC Learn or YouTube selections on air pollution clean-up. • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**3 days**
UNIT 9 AIR – Climate Change **Key Terms:** Greenhouse effect, Greenhouse gases, El Nino-La Nina, topography, Global Climate change, global warming, climate model, fossil fuels, coral bleaching, carbon footprint, Kyoto Protocol. • Textbook Pages 482-513 • Discussion on Essential Questions/Objectives • Lecture and/or teacher generated or textbook PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • Quick Lab pg. 486. • Real Data Exercise pg. 493. • **Performance Task 4:** Find 2-3 news stories from the internet or newspapers that are about: Climate Change and Global Warming, ENSO, Polar melting or Sea Rise. Provide a two paragraph summary of each article. Scoring Rubric Included • NBC Learn or YouTube selections on anthropogenic effects of climate change clean-up. • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**2 Days**
UNIT 9 AIR • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**1 day**

Individual Accommodations

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- Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team.
- Modified worksheets, quizzes and other assignments as required.
- Provide enrichment assignments for early finishers.
- Provide limited Extra Credit assignments.
- Allow for additional time for different learning styles.
- Differentiate instruction for varied learning styles.
- Include technology into the classroom.
- Allow for group interaction.
- Encourage use 'flipped' classroom instruction by students.
- Develop make-up assignments, quizzes and test as required.
- ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature____

Date________________________

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UNIT 10 ENERGY	Number of Days: 24
Content Area: Environmental Science	
Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them. Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, meteorology, botany, biology, chemistry and the social sciences. Many of our objectives, lessons and essential questions will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world. UNIT 10 Energy: There are nine major areas of energy resources. They fall into two categories: nonrenewable and renewable. Nonrenewable energy resources, like coal, nuclear, oil, and natural gas, are available in limited supplies. This is usually due to the long time it takes for them to be replenished. Renewable resources are replenished naturally and over relatively short periods of time. The five major renewable energy resources are solar, wind, water (hydro), biomass, and geothermal. Since the dawn of humanity people have used renewable sources of energy to survive — wood for cooking and heating, wind and water for milling grain, and solar for lighting fires. A little more than 150 years ago people created the technology to extract energy from the ancient fossilized remains of plants and animals. These super-rich but limited sources of energy (coal, oil, and natural gas) quickly replaced wood, wind, solar, and water as the main sources of fuel. Fossil fuels make up a large portion of today's energy market, although promising new renewable technologies are emerging. Careers in both the renewable and nonrenewable energy industries are growing; however, there are differences between the two sectors. They each have benefits and challenges, and relate to unique technologies that play a role in our current energy system. For a range of reasons, from the limited amount of fossil fuels available to their effects on the environment, there is increased interest in using renewable forms of energy and developing technologies to increase their efficiency. Identify energy sources that we use and describe the nature and origin of fossil fuels and evaluate its extraction, use and anthropogenic effects. Evaluate the political, social and economic impacts of fossil fuel use and specify strategies for conserving these resources and energies and enhancing efficiency.	
Grade Level: 9-12	
21st Century Themes	

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	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

21st Century Skills

	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

Materials/Equipment needed:

- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators
- Pearson Textbook and on-line/printed workbook
- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- Maps
- ACHS Media Center – Gale Databases, library collections
- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

- **NBC Learn** news stories/videos about fossil fuels, fracking, oil spills, natural gas, nuclear power, solar power, wind turbines or windmills and more….
- **Chapter or teacher developed PowerPoint's**
- **Student Workbook Assignments – Chapter's 17 & 18**
- **Chapter and Lesson Assessments**
- **Chapter Quiz**
- **Suggested/Optional DVD's** :

YouTube and NBC Learn Videos SEARCH: Fossil Fuels, Oil Spill bioremediation, Fracking, solar energy, wind turbines, alternative energies, nuclear power.

Web-based sites: Fossil Fuels, Alternative Energies, Nuclear Power.

- *Arctic National Wildlife Refuge*, U.S. Fish and Wildlife Service (http://arctic.fws.gov/refugefeatures.htm)
- *Coalbed Methane Outreach Program (CMOP)*, U.S. Environmental Protection Agency (EPA) (www.epa.gov/coalbed)
- *Fossil Fuels*, Office of Fossil Energy, U.S. Department of Energy (www.fossil.energy.gov/education)
- *What Coal Miners Do*, United Mine Workers of America (www.umwa.org/mining/colminrs.shtml)
- *OPEC*, Organization of the Petroleum Exporting Countries (www.opec.org/home)
- *Tar Sands Fever!: It's about water, sand, and oil – but this is no day at the beach*. 2007. WorldWatch Institute. For more information on this issue visit:www.worldwatch.org/ww/tarsands.

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- *Plug-In Hybrids: Our Best Hope*. 2007. Co-op America Quarterly. Today's plug-in hybrids get 100+ mpg, and their emissions are lower than those of any other vehicle on the road today. For more information on transportation issues and plug-in hybrids visit: www.coopamerica.org/go/fuels and www.calcars.org/howtoget.html

- *USNRC Home Page,* United States Nuclear Regulatory Commission (NRC) (www.nrc.gov)

- *Global Nuclear Energy Partnership,* United States Department of Energy (DOE) (www.gnep.energy.gov)

- *Frontline: Why Do Americans Fear Nuclear Power?* WGBH, PBS (www.pbs.org/wgbh/pages/frontline/shows/reaction)

- *Biomass Program,* Energy Efficiency and Renewable Energy, United States Department of Energy (DOE) (www1.eere.energy.gov/biomass)

Audiovisual Materials

- *Energy on Earth,* 2001, distributed by Hawkhill Video (www.hawkhill.com)

- *King Coal, NOW with Bill Moyers*, 2002, PBS Home Video (http://shop.pbs.org)

- *Arctic Quest: Our Search for the Truth,* 2000, produced by Jeff Barrie and Tyson Miller, and distributed by The Video Project (www.videoproject.com)

- *PowerShifts: Energy + Sustainability,* 2003, produced by Kirk Bergstrom, and distributed by The Video Project (www.videoproject.com)

- *The Oil Curse,* 2004, distributed by Films for the Humanities and Science (www.films.com)

- *Oil on Ice*. 2005. DVD. Lightyear Studio production directed by Bo Boduart and Dale Djerassi. Visually stunning tour through the Arctic National Wildlife Refuge with an introduction to its wildlife and people. Shows the politically controversial aspects of what is dubbed, "America's Last Wilderness" through discussions in the halls of Congress to interviews with First Nation people.

- *Nuclear Power,* 1998, distributed by Hawkhill Video (www.hawkhill.com)

- *Radioactive Waste Disposal: The 10,000-Year Test*, distributed by Films for the Humanities & Sciences (www.films.com)

- *Chernobyl Heart: The Dark Side of Nuclear Power,* 2003, distributed by Films for the Humanities & Sciences (www.films.com)

- *American Experience: The Hoover Dam,* PBS Home Video (www.shoppbs.org)

TEACHER Selected Choices:_________________________

Cross-Curricular References/Projects:

ART: Drawing and interpretation skills
Writing: Essay and science research papers

Stage 1: Desired Results (Learning Targets)

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Standards (Include cross-curricular)

Science - NJ 2009 Core Curriculum Content Standards (NJCCCS)

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science. (Grades: 9,10,11,12)

5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. (Grades: 9,10,11,12)

5.1.A Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. (Grades: 9,10,11,12)

5.1.A.5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. (Grades: 9,10,11,12)

5.1.A Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. (Grades: 9,10,11,12)

5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)

5.1.A Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. (Grades: 9,10,11,12)

5.1.A.5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. (Grades: 9,10,11,12)

5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. (Grades: 9,10,11,12)

5.1.B Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. (Grades: 9,10,11,12)

5.1.B.5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. (Grades: 9,10,11,12)

5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)

5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)

5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)

5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standards: **5.3** Life Science: Life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics. (Grades: 9,10,11,12)

5.3.C Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs. (Grades: 9,10,11,12)

5.3.C Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms. (Grades: 9,10,11,12)

5.3.C.5.3.12.C.1 Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem. (Grades: 9,10,11,12)

5.3.C Stability in an ecosystem can be disrupted by natural or human interactions. (Grades: 9,10,11,12)

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5.3.C.5.3.12.C.2 Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations. (Grades: 9,10,11,12)
5.10.5.10.12 B.2 Use scientific, economic, and other data to assess environmental risks and benefits associated with societal activity. (Grades: 9,10,11,12)
Science - NJ 2009 Core Curriculum Content Standards: **5.4** Earth Science:
5.4 Earth Systems Science: Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe. (Grades: 9,10,11,12)
5.4.C Properties of Earth Materials: Earth's composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.1 Model the interrelationships among the spheres in the Earth systems by creating a flow chart. (Grades: 9,10,11,12)
5.4.C The chemical and physical properties of the vertical structure of the atmosphere support life on Earth. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.2 Analyze the vertical structure of Earth's atmosphere, and account for the global, regional, and local variations of these characteristics and their impact on life. (Grades: 9,10,11,12)
5.4.F Climate and Weather: Earth's weather and climate systems are the result of complex interactions between land, ocean, ice, and atmosphere. (Grades: 9,10,11,12)
5.4.F Global climate differences result from the uneven heating of Earth's surface by the Sun. Seasonal climate variations are due to the tilt of Earth's axis with respect to the plane of Earth's nearly circular orbit around the Sun. (Grades: 9,10,11,12)
5.4.F.5.4.12.F.1 Explain that it is warmer in summer and colder in winter for people in New Jersey because the intensity of sunlight is greater and the days are longer in summer than in winter. Connect these seasonal changes in sunlight to the tilt of Earth's axis with respect to the plane of its orbit around the Sun. (Grades: 9,10,11,12)
5.4.F Climate is determined by energy transfer from the Sun at and near Earth's surface. This energy transfer is influenced by dynamic processes, such as cloud cover and Earth's rotation, as well as static conditions, such as proximity to mountain ranges and the ocean. Human activities, such as the burning of fossil fuels, also affect the global climate. (Grades: 9,10,11,12)
5.4.F.5.4.12.F.2 Explain how the climate in regions throughout the world is affected by seasonal weather patterns, as well as other factors, such as the addition of greenhouse gases to the atmosphere and proximity to mountain ranges and to the ocean. (Grades: 9,10,11,12)
5.4.F Earth's radiation budget varies globally, but is balanced. Earth's hydrologic cycle is complex and varies globally, regionally, and locally. (Grades: 9,10,11,12)
5.4.F.5.4.12.F.3 Explain variations in the global energy budget and hydrologic cycle at the local, regional, and global scales. (Grades: 9,10,11,12)

Next Generation Science Standards (NGSS)

HS. Interdependent Relationships in Ecosystems

HS. Weather & Climate

HS. Human Sustainability
HS Earth Science Earth Systems

Students who demonstrate understanding can:
HS-LS2-1. **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical

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comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]

HS-LS2-2. **Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]

HS-LS2-6. **Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS2-8. **Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.**[Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.***[Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

HS-ESS2-4. **Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.*]

HS-ESS3-5. **Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.*]

HS-ESS3-1. **Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [*Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.*]

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geo-engineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.[Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of

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include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [*Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.*] **HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.** [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.] **Other Cross-Curricular Standards** **Writing** techniques, essay and opinion papers, and grammar subjects. MLA/APA Citations **Reading Comprehension** How to read scientific articles and news stories to get relevant evidence and information from them

Enduring Understandings: (What Students will know)	**Essential Questions**
• Select and use appropriate technologies to gather, process, and analyze data to report information related to fossil fuel resources and nuclear power. • Recognizing and analyzing alternative explanations and models. 1.6 Communicate and evaluate scientific thinking that leads to particular conclusions. • Word and chemical equations are used to relate observed changes in matter to its composition and structure. • Quantitative relationships involved with energy can be identified, measured, calculated and analyzed • Energy can be transferred through a variety of mechanisms and in any change some energy is lost as heat (for example: conduction, convection, radiation, motion, electricity, chemical bonding changes). • There are costs, benefits, and consequences of natural resource exploration, development, and	• Define energy and differentiate between kinetic and potential energy. • Identify different forms of energy • Describe how society uses energy. • How are fossil fuels formed? • Describe the uses of oil and how it is extracted • What are the dangers common to oil well drilling in the oceans? • What is coal and why is there so much of it in the United States? • What is Natural Gas? • Why are we mining for Shale in the US currently?

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consumption (for example: geosphere, biosphere, hydrosphere, atmosphere and greenhouse gas) • There are consequences for the use of renewable and nonrenewable resources. • Print and visual media can be evaluated for scientific evidence, bias and opinion • Identify reasons why consensus and peer review are essential to the Scientific Process. • Graphs, equations, or other models are used to analyze systems involving change and constancy • There are cause - effect relationships about the use of fossil fuels versus renewable energy. • Interrelationships among science, technology and human activity lead to further discoveries that impact the world in positive and negative ways.	• Explain why energy conservation is so important? • Discuss the effects of strip mining, groundwater pollution and the environment. • Describe how geothermal energy is harnessed and used. • Define biomass energy and how it is used • Discuss the use of solar power, wind turbines.

Stage 2: Evidence of Learning

Performance Task 1: Mini-lab – Illustrate or PowerPoint the diagram of nuclear reaction power plan and/or a steam turbine to produce electricity and include content about what happens in each aspect and why they interact**.** Scoring Rubric Included
Performance Task 2: Illustrate or PowerPoint the different types of non-renewable and renewable resources and the advantages /disadvantages of each**.**
Performance Task 3: Find 2 news stories from the internet or newspapers that are about: Solar Power, wind Turbines, Fracking for Natural Gas, Coal Mine Pollution, Oil Spills. Provide a two paragraph summary of each article.
Performance Task 4: LAB-Oil Spill Bioremediation

Supplemental Performance Task 1: NAME and EXPLAIN three ways we can reduce our dependence on fossil fuels or NAME and EXPLAIN three ways we can increase our use of solar, wind or geothermal power.

Other evidence of learning:
Chapter quiz
Vocabulary – Student-centered worksheet/puzzles.
Chapter Worksheets:
Key concepts, Flow Charts, Open-ended questions,

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Student Participation:
Student originated questions and debate about lecture topics, chapter issues and current news stories.

Stage 3: Learning Plan	
Objectives	
The Students will know: • Define energy and differentiate between kinetic and potential energy. • Identify different forms of energy • Describe how society uses energy. • How are fossil fuels formed? • Describe the uses of oil and how it is extracted • What are the dangers common to oil well drilling in the oceans? • What is coal and why is there so much of it in the United States? • What is Natural Gas? • Why are we mining for Shale in the US currently? • Explain why energy conservation is so important? • Discuss the effects of strip mining, groundwater pollution and the environment. • Describe how geothermal energy is harnessed and used. • Define biomass energy and how it is used. • Discuss the use of solar power, wind turbines.	**The Students will be able to (TSWBAT):** • Name the major energy sources we use in modern society and compare how this has changed from 200 years ago • Define current worldwide patterns of energy use. • Why is the supply of fossil fuels limited? • Explain how pollutants released from burning fossil fuels are harming our environment. • Explain the implication of our dependence on fossil fuels. • Explain the human health effects caused by burning fossil fuels. • What are the advantages and disadvantages of using nuclear energy? • Explain the benefits of using renewable energies. • What types of renewable energies are there? • Hydroelectric energy, tidal, ocean thermal energy conversion (OTEC) • Discuss the use of solar and wind energies in Atlantic County and NJ • Explain why waste is becoming too much for society to manage. • Define the types of waste and why they are causing so much trouble.

Learning Activities/Instructional Strategies	
Lesson	**Timeframe**
UNIT 10 Energy – Fossil Fuels **Key Terms:** energy, potential and kinetic, renewable-non-renewable, fossil fuels, combustion, electricity, hydraulic fracturing, oil shale, methane hydrate, strip mining, coal, oil, natural gas, nuclear energy, nuclear reactor, nuclear waste, fission. • Textbook Pages 515-547 • Central Case: Oil or wilderness on Alaska's Northern Slope • Discussion on Essential Questions/Objectives • Essential Question: Can we depend on nonrenewable resources for all our energy needs?	**11 days**

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• Lecture and/or teacher generated or textbook PowerPoint • Discuss the types of energy and how we use them. • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • LAB: Quick Lab on where's the energy? Page 520 • DVD-s Gasland or (Teacher Choice) • **Performance Task 1: Mini-lab –** Bio-Remediation of oil spill Scoring Rubric Included • NBC Learn or YouTube selections on Nuclear Power, generating electricity using steam, fracking, oil spills. • **Performance Task 2**: Illustrate or PowerPoint the fossil fuels • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	
UNIT 10 Energy – renewable energies **Key Terms:** air pollution, primary air pollutants, secondary air pollutants, smog, ozone, temperature inversion, acid precipitation**.** • Textbook Pages 548- 579 • Central Case: Germany's BIG BET on Renewable Energy. • BIG Question: What are Potential uses and limitations of renewable energy resources? • REAL Data exercise, pg. 552 • Go Outside Exercise, pg. 564. • **Performance Task 3: Mini-lab –** research two or three articles on-line that deal with storing nuclear waste, solar power, wind turbines or nuclear reactors. Scoring Rubric Included • NBC Learn or YouTube selections on Nuclear Power, generating electricity using steam, fracking, oil spills. • **Performance Task 4**: Illustrate or PowerPoint of the advantages and disadvantages of renewable energies. • Lecture and/or teacher generated or textbook PowerPoint • Unit Vocabulary. (student worksheet or puzzle or crossword) • Student Worksheets • DVD-Documentaries on Renewable energy (Teacher Choice) • **Performance Task 5: Mini-lab –** Build a solar cell to power a small engine or light blub**.** Scoring Rubric Included • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay. • Student (individual or group) project.	**11 days**
UNIT 10 Energy • Chapter quiz/test. Fossil Fuels and Nonrewable Energy • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**2 days**

Individual Accommodations

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- Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team.
- Modified worksheets, quizzes and other assignments as required.
- Provide enrichment assignments for early finishers.
- Provide limited Extra Credit assignments.
- Allow for additional time for different learning styles.
- Differentiate instruction for varied learning styles.
- Include technology into the classroom.
- Allow for group interaction.
- Encourage use ‘flipped’ classroom instruction by students.
- Develop make-up assignments, quizzes and test as required.
- ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature_____________________________________ Date______________________

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UNIT 11 WASTE MANAGEMENT	Number of Days: 15
Content Area: Environmental Science	

Summary of Unit: We can use science to understand the complex interactions between humans and our environment. Environmental Science includes living (biotic) and non-living (abiotic) things like our atmosphere, oceans, forests, farms and all the species both living and extinct. But the study of our environmental would not be complete without the understanding of how our building, highways, industry and man-made systems interact with natural systems. Understanding and resolving environmental problems at the local, regional, or global level require an interdisciplinary perspective; it is necessary to understand how the natural systems of planet function and also that they are being disturbed by human systems that interact with them. Most environmental problems resist solutions from any one discipline. Therefore students gain familiarity with a range of approaches from the natural sciences; such as geology, oceanography, meteorology, botany, biology, chemistry and the social sciences.

Many of our objectives, lessons and essential questions will focus on local environmental problems from the adjacent urban/suburban area and their impact on the surrounding region including the Atlantic Ocean, Absecon and Great Bays and surrounding marshes and estuaries, the NJ Pinelands but the lessons learned from analyzing these local problems are adaptable to other locales and situations throughout our world.

UNIT 11 Waste Management:

Americans alone are responsible for producing a hopping 220 million tons of waste a year. This number is far more than any other nation in the world. Because of this fact both the government and environmental associations have developed numerous methods of dealing with the problem. Waste management is that solution, a rather complex issue that encompasses more than 20 different industries. Waste management is collection, transportation, and disposal of garbage, sewage and other waste products.

Waste management is the process of treating solid wastes and offers variety of solutions for recycling items that don't belong to trash. It is about how garbage can be used as a valuable resource. Waste management is something that each and every household and business owner in the world needs. Waste management disposes of the products and substances that you have use in a safe and efficient manner.

You will find there are eight major groups of waste management methods, each of them divided into numerous categories. Those groups include source reduction and reuse, animal feeding, recycling, composting, fermentation, landfills, incineration and land application. You can start using many techniques right at home, like reduction and reuse, which works to reduce the amount of disposable material used.

Grade Level: 9-12

21st Century Themes

	Global and local Awareness of our place in environment.		Civic and Social Responsibility.		Environmental Issues: advocacy, sustainability, ethics and legal.		Science current events & topics

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21st Century Skills							
	Critical thinking.		Decision-making skills.		Writing/vocabulary skills.		Life and Career skills
	Media Literacy.		Basic Math Skills.		Modeling, graphing & interpreting data		

Integration of Technology:
Computers, Internet, Calculators, Scientific Instruments.

Materials/Equipment needed:

- Writing, graph, and/or art paper, pencils, pens, markers, rulers, calculators
- Pearson Textbook and on-line/printed workbook
- Computers with internet access
- DVD, Player, Screen
- NBC Learn/YouTube/eChalk
- Google Docs
- maps
- ACHS Media Center – Gale Databases, library collections
- Specific Lab equipment and supplies
- Teacher selected materials

Unit Resources/References Needed: (related websites, reference materials, worksheets, etc.)

- **DVD: Suggested DVD's (select one or parts from one as time appropriate…)**
- **DVD: Trashed**
- **DVD: Wasteland (http://www.wastelandmovie.com/)**
- Your choices________________________
- **NBC Learn** news stories videos about waste management, plastic, garbage, landfills and more….
- **Chapter or teacher developed PowerPoint's**
- **Student Workbook Assignments – Chapter 19**
- **Chapter and Lesson Assessments**
- **Chapter Quiz**
- **Suggested/Optional DVD's** :

YouTube and NBC Learn Videos SEARCH: waste management, plastic, garbage, landfills

Web-based sites: Waste Management and garbage

Cross-Curricular References/Projects:

ART: Drawing and interpretation skills
Writing: Essay and science research papers

Stage 1: Desired Results (Learning Targets)

Standards (Include cross-curricular)

Science - NJ 2009 Core Curriculum Content Standards (NJCCCS)

5.1 Science Practices: Science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands

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encompass the knowledge and reasoning skills that students must acquire to be proficient in science. (Grades: 9,10,11,12)
5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world. (Grades: 9,10,11,12)
5.1.A Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. (Grades: 9,10,11,12)
5.1.A Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories. (Grades: 9,10,11,12)
5.1.A Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence. (Grades: 9,10,11,12)
5.1.A.5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence. (Grades: 9,10,11,12)
5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims. (Grades: 9,10,11,12)
5.1.B Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. (Grades: 9,10,11,12)
5.1.B Mathematical tools and technology are used to gather, analyze, and communicate results. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. (Grades: 9,10,11,12)
5.1.B Empirical evidence is used to construct and defend arguments. (Grades: 9,10,11,12) 5.1.B.5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. (Grades: 9,10,11,12) 5.1.B Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions. (Grades: 9,10,11,12)
5.1.B.5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. (Grades: 9,10,11,12)

Science - NJ 2009 Core Curriculum Content Standards: **5.3** Life Science: Life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics. (Grades: 9,10,11,12)
5.3.C Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs. (Grades: 9,10,11,12)
5.3.C Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms. (Grades: 9,10,11,12)
5.3.C.5.3.12.C.1 Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem. (Grades: 9,10,11,12)
5.3.C Stability in an ecosystem can be disrupted by natural or human interactions. (Grades: 9,10,11,12)
5.3.C.5.3.12.C.2 Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations. (Grades: 9,10,11,12)
5.10.5.10.12 B.2 Use scientific, economic, and other data to assess environmental risks and benefits associated with societal activity. (Grades: 9,10,11,12)
Science - NJ 2009 Core Curriculum Content Standards: **5.4** Earth Science:

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5.4 Earth Systems Science: Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe. (Grades: 9,10,11,12)
5.4.C Properties of Earth Materials: Earth's composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.1 Model the interrelationships among the spheres in the Earth systems by creating a flow chart. (Grades: 9,10,11,12)
5.4.C The chemical and physical properties of the vertical structure of the atmosphere support life on Earth. (Grades: 9,10,11,12)
5.4.C.5.4.12.C.2 Analyze the vertical structure of Earth's atmosphere, and account for the global, regional, and local variations of these characteristics and their impact on life. (Grades: 9,10,11,12)
5.4.F Climate and Weather: Earth's weather and climate systems are the result of complex interactions between land, ocean, ice, and atmosphere. (Grades: 9,10,11,12)
5.4.F Global climate differences result from the uneven heating of Earth's surface by the Sun. Seasonal climate variations are due to the tilt of Earth's axis with respect to the plane of Earth's nearly circular orbit around the Sun. (Grades: 9,10,11,12)
5.4.F.5.4.12.F.1 Explain that it is warmer in summer and colder in winter for people in New Jersey because the intensity of sunlight is greater and the days are longer in summer than in winter. Connect these seasonal changes in sunlight to the tilt of Earth's axis with respect to the plane of its orbit around the Sun. (Grades: 9,10,11,12)
5.4.F Climate is determined by energy transfer from the Sun at and near Earth's surface. This energy transfer is influenced by dynamic processes, such as cloud cover and Earth's rotation, as well as static conditions, such as proximity to mountain ranges and the ocean. Human activities, such as the burning of fossil fuels, also affect the global climate. (Grades: 9,10,11,12)
5.4.F.5.4.12.F.2 Explain how the climate in regions throughout the world is affected by seasonal weather patterns, as well as other factors, such as the addition of greenhouse gases to the atmosphere and proximity to mountain ranges and to the ocean. (Grades: 9,10,11,12)
5.4.F Earth's radiation budget varies globally, but is balanced. Earth's hydrologic cycle is complex and varies globally, regionally, and locally. (Grades: 9,10,11,12)
5.4.F.5.4.12.F.3 Explain variations in the global energy budget and hydrologic cycle at the local, regional, and global scales. (Grades: 9,10,11,12)

Next Generation Science Standards (NGSS)

HS. Interdependent Relationships in Ecosystems

HS. Weather & Climate

HS. Human Sustainability
HS Earth Science Earth Systems

Students who demonstrate understanding can:

HS-LS2-1. **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]

HS-LS2-2. **Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different**

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	scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]
HS-LS2-6.	**Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]
HS-LS2-7.	**Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]
HS-LS2-8.	**Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.**[Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]
HS-LS4-6.	**Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.***[Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]
HS-ESS2-4.	**Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.*]
HS-ESS3-5.	**Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.*]
HS-ESS3-1.	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]
HS-ESS3-2.	**Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*** [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible,

and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [*Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.*]

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geo-engineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.[Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [*Assessment*

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Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.]

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

Other Cross-Curricular Standards
Writing techniques, essay and opinion papers, and grammar subjects. MLA/APA Citations
Reading Comprehension How to read scientific articles and news stories to get relevant evidence and information from them

Enduring Understandings: (What Students will know)	**Essential Questions**
• Explain why waste is becoming too much for society to manage. • Define the types of waste and why they are causing so much trouble. • Hazardous wastes: nuclear, toxic chemicals, oil, drugs and others.	• Methods of solid waste disposal • What is recycling and biodegradable? • What is source reduction? • Waste Treatment Plants Why is the earth and its atmosphere like a greenhouse?

Stage 2: Evidence of Learning

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Performance Task 1: Mini-lab – Illustrate or PowerPoint the steps in wastewater treatment and include content about what happens in each step and why they interact**.** Scoring Rubric Included **Performance Task 2**: Illustrate or PowerPoint the different types of waste disposal**.** **Performance Task 3:** Find 2 news stories from the internet or newspapers that are about: the great pacific garbage patch, plastics, landfill, plasma incineration of waste, recycling methods and uses of recycled material. **Performance Task 4:** Write a research paper about the ACUA waste treatment plant Two-three pages typed.. Scoring Rubric Included **Supplemental Performance Task 1:** Build an actual waste treatment experiment showing how everyday items decompose and degrade or not!
Other evidence of learning: Chapter quiz Vocabulary – Student-centered worksheet/puzzles. Chapter Worksheets: Key concepts, Flow Charts, Open-ended questions, Student Participation: Student originated questions and debate about lecture topics, chapter issues and current news stories.

Stage 3: Learning Plan	
Objectives	
The Students will know: What is Solid Waste How and Why we treated to dispose of it. Why we need new methods of treating solid waste. What are the types of waste pollution? Processes of Waste Management.	**The Students will be able to (TSWBAT):** Summarize and compare the types of waste we generate List the major approaches to managing waste Delineate the scale of the waste dilemma Describe the conventional waste disposal methods: landfills and incineration Evaluate approaches for reducing waste: source reduction, reuse, composting, and recycling Discuss industrial solid waste management and principles of industrial ecology Assess issues in management of hazardous waste

Learning Activities/Instructional Strategies	
Lesson	**Timeframe**
UNIT 10 Waste Management **Key Terms:** • Textbook Pages 580-609 • Central Case: Transforming New York's Fresh Kills LANDFILL • Discussion on Essential Questions/Objectives • Explain the • Lecture and/or teacher generated or textbook PowerPoint • Discuss the types of weather fronts and how they form. • Unit Vocabulary. (student worksheet or puzzle or crossword)	**3 days**

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• Student Worksheets • LAB: Quick Lab: on Reduce-Reuse-Recycle textbook Page 591 • Real Data Exercise on page 601 • DVD-Water Uses (Teacher Choice) • **Performance Task 1: Mini-lab –** Discussion about the Recycling Process on page 604-605 and how it relates to ACUA in Atlantic City Scoring Rubric Included • NBC Learn or YouTube selections on waste management, landfills, recycling, and great pacific garbage patch. • **Performance Task 2**: Illustrate or PowerPoint a typical landfill schematic • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	
UNIT 10 Waste Management **Key Terms:** Landfill, leachates, hazardous waste, solid waste, waste treatment, composting waste-to-energy, municipal waste, industrial waste, chemical wastes, nuclear waste	**3 days**
UNIT 10 Waste Management • Chapter quiz/test • Assess student skills and mastery of concepts and issues through use of: class discussion/debate, open-ended questions, multiple choice and essay.	**1 day**

Individual Accommodations
• Read, discuss and address all Student IEP and Special Education Plans with Guidance and/or Child Study Team. • Modified worksheets, quizzes and other assignments as required. • Provide enrichment assignments for early finishers. • Provide limited Extra Credit assignments. • Allow for additional time for different learning styles. • Differentiate instruction for varied learning styles. • Include technology into the classroom. • Allow for group interaction. • Encourage use 'flipped' classroom instruction by students. • Develop make-up assignments, quizzes and test as required. • ESL adaptations as available.

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LESSON REFLECTION

The teacher should complete the Lesson Reflection Form after each week of lessons. This form may be used to revise curriculum.

Teacher: Grade/Subject

Lessons taught:

	Not at All	Not Much	Some	A Lot	Totally
Was the lesson plan followed?					
Would you recommend this lesson be used again next year?					
Do you think the students understood the lesson?					
Were there any parts of the lesson in which content was too…					
easy for the students to understand?					
what parts?					
difficult for the students to understand?					
what parts?					
Were there any problems with this lesson?					
Explain.					

1. As I reflect on the lesson(s), to what extent were the students productively engaged in the work? How do I know?

2.What feedback did I receive from students indicating they achieved understanding and that the goal/objectives were met for this lesson?

3. Did I adjust my teaching strategies and activities as I taught the lesson? Why? How?

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4. If I had the opportunity to teach this lesson again to this same group of students, what would I do differently or what would I like to share with a colleague? How can this improve?

5. Was the timing of the lesson accurate?

6. Other

Teacher's Signature_____________________________________
Date______________________

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Marine Science Academic

9th 10th 11th & 12th Grades

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

Curriculum: Steve Nagiewicz, Science Teacher

(August 2018 DRAFT)

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XXIX. OVERVIEW

Marine Science is an interdisciplinary science course that will provide students with an awareness of the basic concepts of Physical Sciences and Life Sciences to include; comprising of archaeology, astronomy, biology, chemistry, climatology, geography, geology, hydrology, meteorology and physics. Paleoceanography studies the history of the oceans in the geologic past and combines them with principles of social, economic, and moral ethics.

The course allows each student to analyze and decide current issues concerning management of the oceans in order to maintain or improve the quality of life on earth. This course is designed to provide students with the scientific principles, concepts and methodologies required to understand the interrelationships of the natural world, to identify and analyze ocean-related issues and environmental problems (natural and human-made), to evaluate the relative risks associated with these current problems and to examine for resolving and/or preventing them. This Honors course meets for five single periods a week and include one additional period/day which will be a laboratory demonstration of a key concept.

XXX. RATIONALE

Our Oceans comprise over 70% of the Earth's surface and contain an intricately balanced mixture of atmosphere and sea to regulate climate, produce food, and provide travel. Various environmental problems and ecological limits are real and will be affecting all of us in various ways for the rest of our lives. To successfully meet these challenges, it is necessary that we, as individuals and as a society, fully understand the nature of our interactions with our oceans and the impact humans have on our oceans, atmosphere and the life contain within. The overall objective of this course is to describe the importance of our marine environment and the constraints which humankind confronts and to show the courses of action which may be taken in order to cope successfully with them.

XXXI. TEXTBOOK

Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed Meets Next Generation Science Standards (NGSS) and Common Core State Standards (CCCS)

Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed offers data driven investigations, meaningful context-based activities and lessons that seamlessly integrate Science, Technology, Engineering and Mathematics (STEM) for the deeper conceptual understanding valued by the Next Generation Science Standards (NGSS).

NGSS focuses the developmental progression through Disciplinary Core Ideas on a core understanding of content and the application of knowledge in real-world scenarios. From cover to cover, **Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed** is built on the integrated STEM philosophy that drives NGSS.

Lessons are thoughtfully sequenced to build strong, conceptual understanding of the ocean and the Earth as a system, and make real-life data driven connections that are interesting and meaningful to today's high school students.

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Foundations of NGSS and Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed. Nature of Science (NOS) A deep understanding of the NOS is essential to a strong science education and highly valued in Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed. The text directly addresses important NOS terminology and contextualizes examples of how science is conducted in everyday life. The course highlights the tenets of the NOS in each lesson to show the educator exactly how the content helps students learn and apply principles, to ensure that NOS is a consistent, underlying theme.

Science and Engineering Practices

Inquiry as a scientific practice is central to the development of Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed. The application of concepts to socio-scientific issues which inspire meaningful discourse and justification of ideas occurs throughout exciting investigations of marine ecosystems. Students engage in an exploration of the threats to marine life and the responsibility of humans to protect the ocean and its vast resources. They employ the Engineering Design Process, which incorporates NGSS's eight practices of science and engineering to investigate point source pollution and design ways to effectively clean up oil spills. Throughout the course, students demonstrate a deep understanding of scientific concepts through the application of engineering.

Crosscutting Concepts

The field of Marine Science is truly interdisciplinary, void of conceptual boundaries. Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed includes exciting applications of STEM that demonstrate bridging concepts across disciplines in the exciting context of the ocean. Examples of some topics covered in Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed that demonstrate NGSS Crosscutting Concepts:

1. Patterns.
   Classification of marine organisms; structure and function; biological evolution; properties of matter; properties of water
2. Cause and effect: Mechanism and explanation
   Scientific investigations; engineering practices; impacts of coastal development; symbiotic relationships between species
3. Scale, proportion, and quantity.
   Population dynamics
4. Systems and system models.
   Using models to demonstrate various concepts: 1) transfer of energy; 2) using engineering design to address pollution challenges; 3) studying human induced habitat destruction; 4) identifying solutions
5. Energy and matter: Flows, cycles, and conservation.
   Cycling of energy and matter; biogeochemical cycles; conservation of energy
6. Structure and function.
   Study of marine animals; adaptations to marine environments
7. Stability and change.
   Population dynamics, coevolution; natural selection

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XXXII. **STANDARDS**

The following list identifies the cross-referencing of the NextGen Science Standards of 2017-18 and the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (January 2017).

Next Gen Science Standards (NGSS)

Lesson Title	NGSS High Disciplinary Core Idea code
Diving into Ocean Ecosystems	HS-LS2-3
Water on Earth	HS-ESS2-5, HS-PS1-5, HS-PS1-1
More about Water	HS-ESS2-5, HS-PS1-2, HS-PS1-3
The Ocean over time	HS-ESS3-1, HS-ESS3-4
Migrations in the Sea	HS-PS4-5, HS-PS4-2
Explore the Sea Floor	HS-PS4-5
The Formation of the Ocean	HS-ESS1-5 , HS-ESS2-1 , HS-ESS2-1, HS-ESS2-3,
Seasons of Change	HS-ESS2-1, HS-PS4-3, HS-ESS2-4
The Sea Surface	HS-PS3-2, HS-ESS2-4, HS-ESS2-5
Energy and the Ocean	HS-PS3-1, HS-PS3-2, HS-PS3-4
Weather, Climate and the Ocean	HS-ESS2-2
Voyage to the Deep	HS-ESS2-2
Photosynthesis in the Ocean	HS-LS1-5, HS-LS2-5, HS-ESS2-4, HS-ESS2-5.
Biodiversity in the Ocean	HS-LS1-1, HS-LS1-2
Marine Populations	HS-LS1-4, HS-LS2-1, HS-LS2-2, HS-LS2-6, HS-LS2-8, HS-ESS2-7, HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4, HS-LS4-5, HS-LS3-3, HS-LS2-2, HS-LS2-8
Food Webs in Action	HS-ESS2-6, HS-LS1-7, HS-LS2-3, HS-LS2-4
Introduction to Marine Invertebrates	HS-LS1-2
Biology of Fishes	HS-LS4-3, HS-LS1-1
Marine Reptiles and birds	HS-LS4-3
Marine Mammals	HS-LS1-4, HS-LS2-8
Relationships in the Sea	HS-LS2-8
The Ocean's Waves	HS-PS4-1
A Time for Tides	HS-ESS1-4
Animal Needs and Animal Tracking	HS-PS4-2
Student Expert Research	HS-PS4-4
Student Expert Analysis	HS-PS4-4
Which Way to the Sea	HS-ESS2-1, HS-ESS2-2, HS-ESS1-6, HS-ESS2-7
Nonpoint Source Pollution	HS-LS4-6
Point source oil pollution	HS-ESS3-2, HS-ESS3-4, HS-ESS3-6, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-LS4-6
Humans and Coastlines	HS-ESS3-1, HS-LS2-7
The Ocean's Resources	HS-ESS3-1
Changing Climate	HS-ESS2-2, HS-ESS2-4, HS-ESS3-5, HS-ESS2-7
Protecting Marine Habitats	HS-ESS3-6, HS-LS2-7

**** Lessons and curriculum standards based upon recommended textbook**

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Science - NJ 2009 Core Curriculum Content Standards

5.1 Science Practices: All students will understand that science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.

5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world.

5.1.A.5.1.12.A.1 Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles.

CPI: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.

5.1.A.5.1.12.A.2 Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.

CPI: Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.

5.1.A.5.1.12.A.3 Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence.

CPI: Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.

5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims.

5.1.B.5.1.12.B.1 Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.

CPI: Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data.

5.1.B.5.1.12.B.2 Mathematical tools and technology are used to gather, analyze, and communicate results.

CPI: Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.

5.1.B.5.1.12.B.3 Empirical evidence is used to construct and defend arguments.

CPI: Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.

5.1.B.5.1.12.B.4 Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.

CPI: Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.

5.1.C Reflect on Scientific Knowledge: Scientific knowledge builds on itself over time.

5.1.C.5.1.12.C.1 Refinement of understandings, explanations, and models occurs as new evidence is incorporated.

CPI: Reflect on and revise understandings as new evidence emerges.

5.1.C.5.1.12.C.2 Data and refined models are used to revise predictions and explanations.

CPI: Use data representations and new models to revise predictions and explanations

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5.1.C.5.1.12.C.3 Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges.

CPI: Consider alternative theories to interpret and evaluate evidence-based arguments.

5.1.D Participate Productively in Science: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms.

5.1.D.5.1.12.D.1 Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.

CPI: Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.

5.1.D.5.1.12.D.2 Science involves using language, both oral and written, as a tool for making thinking public.

CPI: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.

5.1.D.5.1.12.D.3 Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically.

CPI: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.

5.2 Physical Science: All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

5.2.A. Properties of Matter: All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia.

5.2.12.A.6 Acids and bases are important in numerous chemical processes that occur around us, from industrial to biological processes, from the laboratory to the environment.

CPI: Relate the pH scale to the concentrations of various acids and bases.

5.2.B. Changes in Matter: Substances can undergo physical or chemical changes to form new substances. Each change involves energy.

5.2.12.B.2 A large number of important reactions involve the transfer of either electrons or hydrogen ions between reacting ions, molecules, or atoms. In other chemical reactions, atoms interact with one another by sharing electrons to create a bond.

CPI: Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel.

5.3 Life Science: All students will understand that life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics.

5.3.B. Matter and Energy Transformations: Food is required for energy and building cellular materials. Organisms in an ecosystem have different ways of obtaining food, and some organisms obtain their food directly from other organisms.

5.3.12.B.3 Continual input of energy from sunlight keeps matter and energy flowing through ecosystems.

CPI: Predict what would happen to an ecosystem if an energy source was removed.

5.3.12.B.5 In both plant and animal cells, sugar is a source of energy and can be used to make other carbon-containing (organic) molecules.

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CPI: Investigate and describe the complementary relationship (cycling of matter and flow of energy) between photosynthesis and cellular respiration

5.3.12.B.6 All organisms must break the high-energy chemical bonds in food molecules during cellular respiration to obtain the energy needed for life processes.

CPI: Explain how the process of cellular respiration is similar to the burning of fossil fuels

5.3.C. Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs.

5.3.12.C.1 Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms.

CPI: Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem.

5.3.12.C.2 Stability in an ecosystem can be disrupted by natural or human interactions.

CPI: Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations.

5.3.E. Evolution and Diversity: Sometimes, differences between organisms of the same kind provide advantages for surviving and reproducing in different environments. These selective differences may lead to dramatic changes in characteristics of organisms in a population over extremely long periods of time.

5.3.12.E.2 Molecular evidence (e.g., DNA, protein structures, etc.) substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched.

CPI: Estimate how closely related species are, based on scientific evidence. The principles of evolution (including natural selection and common descent) provide a scientific explanation for the history of life on Earth as evidenced in the fossil record and in the similarities that exist within the diversity of existing organisms

5.4 Earth Systems Science: All students will understand that Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe.

5.4.B. History of Earth: From the time that Earth formed from a nebula 4.6 billion years ago, it has been evolving as a result of geologic, biological, physical, and chemical processes.

5.4.12.B.1 The evolution of life caused dramatic changes in the composition of Earth's atmosphere, which did not originally contain oxygen gas.

CPI: Trace the evolution of our atmosphere and relate the changes in rock types and life forms to the evolving atmosphere.

5.4.C. Properties of Earth Materials: Earth’s composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life.

5.4.12.C.1 Soils are at the interface of the Earth systems, linking together the biosphere, geosphere, atmosphere, and hydrosphere.

CPI: Model the interrelationships among the spheres in the Earth systems by creating a flow chart.

5.4.12.C.2 The chemical and physical properties of the vertical structure of the atmosphere support life on Earth.

CPI: Analyze the vertical structure of Earth's atmosphere, and account for the global, regional, and local variations of these characteristics and their impact on life.

5.4.D. Tectonics: The theory of plate tectonics provides a framework for understanding the dynamic processes within and on Earth.

5.4.12.D.1 Convection currents in the upper mantle drive plate motion. Plates are pushed apart at spreading zones and pulled down into the crust at subduction zones.

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CPI: Explain the mechanisms for plate motions using earthquake data, mathematics, and conceptual models.

5.4.12.D.2 Evidence from lava flows and ocean-floor rocks shows that Earth's magnetic field reverses (North - South) over geologic time.

CPI: Calculate the average rate of seafloor spreading using archived geomagnetic-reversals data.

5.4.E. Energy in Earth Systems: Internal and external sources of energy drive Earth systems.

5.4.12.E.1 The Sun is the major external source of energy for Earth's global energy budget.

CPI: Model and explain the physical science principles that account for the global energy budget.

5.4.12.E.2 Earth systems have internal and external sources of energy, both of which create heat.

CPI: Predict what the impact on biogeochemical systems would be if there were an increase or decrease in internal and external energy.

5.4.F. Climate and Weather: Earth's weather and climate systems are the result of complex interactions between land, ocean, ice, and atmosphere.

5.4.12.F.1 Global climate differences result from the uneven heating of Earth's surface by the Sun. Seasonal climate variations are due to the tilt of Earth's axis with respect to the plane of Earth's nearly circular orbit around the Sun.

CPI: Explain that it is warmer in summer and colder in winter for people in New Jersey because the intensity of sunlight is greater and the days are longer in summer than in winter. Connect these seasonal changes in sunlight to the tilt of Earth's axis with respect to the plane of its orbit around the Sun.

5.4.12.F.2 Climate is determined by energy transfer from the Sun at and near Earth's surface. This energy transfer is influenced by dynamic processes, such as cloud cover and Earth's rotation, as well as static conditions, such as proximity to mountain ranges and the ocean. Human activities, such as the burning of fossil fuels, also affect the global climate.

CPI: Explain how the climate in regions throughout the world is affected by seasonal weather patterns, as well as other factors, such as the addition of greenhouse gases to the atmosphere and proximity to mountain ranges and to the ocean.

5.4.12.F.3 Earth's radiation budget varies globally, but is balanced. Earth's hydrologic cycle is complex and varies globally, regionally, and locally.

CPI: Explain variations in the global energy budget and hydrologic cycle at the local, regional, and global scales.

5.4.G. Biogeochemical Cycles: The biogeochemical cycles in the Earth systems include the flow of microscopic and macroscopic resources from one reservoir in the hydrosphere, geosphere, atmosphere, or biosphere to another, are driven by Earth's internal and external sources of energy, and are impacted by human activity.

5.4.12.G.1 Natural and human-made chemicals circulate with water in the hydrologic cycle.

CPI: Analyze and explain the sources and impact of a specific industry on a large body of water (e.g., Delaware or Chesapeake Bay)

5.4.12.G.2 Natural ecosystems provide an array of basic functions that affect humans. These functions include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients.

CPI: Explain the unintended consequences of harvesting natural resources from an ecosystem.

5.4.12.G.3 Movement of matter through Earth's system is driven by Earth's internal and

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external sources of energy and results in changes in the physical and chemical properties of the matter.

CPI: Demonstrate, using models, how internal and external sources of energy drive the hydrologic, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles.

5.4.12.G.4 Natural and human activities impact the cycling of matter and the flow of energy through ecosystem.

CPI: Compare over time the impact of human activity on the cycling of matter and energy through ecosystems.

5.4.12.G.5 Human activities have changed Earth's land, oceans, and atmosphere, as well as its populations of plant and animal species.

CPI: Assess (using maps, local planning documents, and historical records) how the natural environment has changed since humans have inhabited the region.

5.4.12.G.6 Scientific, economic, and other data can assist in assessing environmental risks and benefits associated with societal activity.

CPI: Assess (using scientific, economic, and other data) the potential environmental impact of large-scale adoption of emerging technologies (e.g., wind farming, harnessing geothermal energy)

5.4.12.G.7 Earth is a system in which chemical elements exist in fixed amounts and move through the solid Earth, oceans, atmosphere, and living things as part of geochemical cycles.

CPI: Relate information to detailed models of the hydrologic, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles, identifying major sources, sinks, fluxes, and residence times

STUDENT OUTCOMES

A. KNOWLEDGE (Information and Concepts)
   The students will (verbally or in writing):
   1. Define, in writing/discussion, the concept of our ocean ecosystem including identifying abiotic and biotic components, explaining the importance of climatology and our weather, deep ocean exploration as well as sustainable fisheries, protection of endangered animals.
   2. Determine, from evidence given, whether ocean ecosystems are stable or in danger of collapse.
   3. Describe, in writing/discussion/project, the key chemical concepts and processes responsible for maintaining ocean environmental stability. For example, sustainable fisheries and protection of endangered species
   4. Explain, in writing/discussion/project, the dynamic balance that exists among the components that make up ocean.
   5. Discuss, in writing/discussion, the hydrologic cycle and how it helps connect all ecosystems together and to describe the effect that man has had on it.
   6. Describe the impact of domestic pollution and wastes on the ocean and the existence of humankind.
   7. Summarize and state in writing, several key concepts presented in news articles as they relate to marine science research, advocacy and ethics.
   8. Explain, in writing, the limits to growth with respect to living with a finite quantity of resources.
   9. Summarize, in writing/discussion/project, as many diverse opinions and scientific principles that need to be researched in order to attempt to answer questions such as

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"Can ocean pollution be controlled?" and "What will future marine mammals population decreases do to the ocean environment?"

10. Recognize, in writing/discussion, current and past leaders of marine science and their contributions.

B. ATTITUDES

The student will:

1. Develop an appreciation for the study of marine science and how it relates to his/her everyday life.
2. Research and investigate possible careers in marine science
3. Recognize the impact of marine science on every aspect of daily life.

C. SKILLS AND BEHAVIOR

The student will:

1. Demonstrate good problem-solving techniques
2. Write essays on specific topics in marine science demonstrating comprehension of a given topic, i.e. the historical development of the subject
3. Demonstrate effective listening and note taking skills in lecture and discussion situations
4. Demonstrate proper and safe use of laboratory equipment and chemicals during experiments
5. Use the scientific method in solving laboratory based problems and writing reports based on their solutions
6. Demonstrate in class discussion and in writing a comprehensive knowledge of marine science
7. Work cooperatively in small groups to solve problems or perform experiments
8. Design and interpret graphs using data
9. Use spreadsheet and graphing software to report results of laboratory investigations
10. Design and produce presentations using Power Point presentation software
11. Set up and perform experiments using computer interfaced sensors to collect data
12. Utilize Internet search engines to locate environmental science related websites for research and review

XXXIII. ACCOMMODATIONS AND MODIFICATIONS

The NextGen Science Standards (NGSS) and the New Jersey Core Curriculum Content Standards (NJCCCS) reflect concepts that all children need to grow intellectually, socially and emotionally. Goals and objectives for all students, no matter how significant their learning challenges, should be related to the NGSS & NJCCCS and associated cumulative progress indicators. Working within the framework of the standards, using accommodations and modifications as needed, will prepare students to proficiently participate in the *Partnership for Assessment of Readiness for College and Careers* (PARCC) College Board (PSAT) and (SAT) Assessments and New Jersey Assessment of Skills and Knowledge (NJ ASK) or the Alternative Proficiency Assessment (APA).

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The Special Education Department will follow the district's general education curricula, reflecting the following New Jersey Core Curriculum Content Standards (NJCCCS). These standards and related curriculum frameworks are the focus of curriculum and instruction for all students.

Curriculum and instructional adaptations may be required in order to provide meaningful assessment and exposure to the material based on the content standards. "The adaptations are not intended to compromise the content standards. Instead, adaptations provide students with disabilities the opportunity to maximize their strengths and compensate for their learning differences." (**New Jersey Department of Education** Cross-Content Framework, p 7.1, Appendix B)

Accommodations refer to the actual teaching supports and services that the student may require to successfully demonstrate learning. Accommodations should not change expectations to the curriculum grade levels. Accommodations may include but are not limited to: taped books, math charts, additional time, oral test, oral reports, preferred seating, study carrel, amplified system, braille writer, adapted keyboard, specialized software, etc.

Modifications refer to changes made to curriculum expectations in order to meet the needs of the student. Modifications are made when the expectations are beyond the student's level of ability. Modifications may be minimal or very complex depending on the student performance. Modifications must be clearly acknowledged in the IEP. Modifications may include but are not limited to: second language exemptions, withdrawal for specific skills, include student in same activity but individualize the expectations and materials, student is involved in same theme/unit but provide different task and expectations, etc.

V. INSTRUCTIONAL STRATEGIES

The following strategies/activities will be used:

NOTE: The suggested activities provided in this document are ideas for the teacher. If the teacher chooses to develop his/her own activity, *it must be of equal or better quality and at the same or higher cognitive levels.*

- Audio visual media
- Charts, handouts, graphs
- Class & individual assignments
- Cooperative activities
- Critical thinking:
  - Decision making
  - Compare & contrast
  - Reliable sources
  - Causal explanation
  - Prediction
- Debates & panel discussion
- Demonstrations (teacher/student led)
- Direct instruction
- Discussion (teacher/student led)
- Drill practice
- Extra credit project or presentation
- Homework
- Investigation
- Laboratory experiment
- Lecture

Library and resource documents
Oral reading
Periodicals
Questioning techniques
Research paper
Reviews
Self-instructional instruments
Textbook
Textbook supplements
Tutoring (peer & teacher)

VI. EVALUATION

NOTE: Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.

Assessments may include
DERIVED ASSESSMENT *inferred from student's ability to respond to items on paper.*
Tests
Quizzes
Homework
Pre and Post Quarterly assessments

AUTHENTIC ASSESSMENT *based on behavior, product, or outcome.*
Class participation
Teacher observation
Infusion exercises
Portfolios

PERFORMANCE ASSESSMENT *authentic assessment specific to environmental science.*
Laboratory

VII. REQUIRED RESOURCES

Student resources:

1. **Textbook:** *Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Edition, AMSCO.*
2. Technology: Chromebook cart. Google and Google Documents/Drive, EdConnect, and Internet Resources, textbook/publisher web resources.
3. Addition resources:
   Reference materials
   Audio-visual materials, DVD's
   Computer software
   NBC Learn
   YouTube videos
   Media center internet reference and data search
   Textbook Marie Science: The Dynamic Ocean.

Textbook: Introduction into the Biology of Marine Life, James Sumich. 8th Edition.
   Alternative assessment activities

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VIII. SCOPE AND SEQUENCE

UNIT 1 – Introduction to Marine Science.

SEPTEMBER

Science Basics Review

Chapter 1. Exploring the Oceans.

Understand the major physiographic provinces of the marine environment.
Diversity and distribution of marine organisms
Describe the basis for the coral-reef ecosystem.
Understanding geography and bathymetry.
Describe the types of coral reefs, namely fringing reefs, barrier reefs, and atolls.
Types of Ocean Ecosystems Overview: Rocky Shores, Sandy Beaches
Kelp Forests, Mangroves and Swamps, Types of Estuaries, and Salt Marshes, Mudflats

Chapter 2. Science as Inquiry**.**

Scientific Method, Scientific Measurements, science project and research paper
Steps of the Scientific Method
Science Math, Measurements & Statistics
Reading & Understanding Graphs
Using geography, maps & charts
Lab Procedures, Safety and Reports
Solving scientific problems

Chapter 3 Marine Science and Technology

Types of Ocean Technology and Science and how data is used, Scuba Diving,
Oceans and people, careers in Marine Science.
History of the Oceans-Timeline
Shipwrecks and Marine Archaeology
Ocean Technologies
Using technology to explore the deep ocean.
Scuba Diving, submarines, robotics.
Sea Perch ROV's

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports
Benchmark Pre-Test

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OCTOBER

UNIT #5. The Water Planet
Chapter 15. The World of Water
Chemical and physical properties of the water and seawater
Water-the three States of Matter
Density
Floating and water molecules
Color and visibility
Chemical and physical properties of the water and seawater
Water is the Universal Solvent
Effects of Pressure and depth
Cohesion
Salinity of water and its properties and effects

Chapter 16. Geology and the Ocean.
Formation of the ocean
The theory of plate tectonics
Three types of crustal movement
Volcanoes, Earthquakes and Tsunamis
Dangerous Tsunami's
Evidence of seafloor spreading
Black Smoking Vents
Deepsea trenches Understand the geography of the ocean
Types of geography on the seafloor-Ocean Basin, guyots, mountains, trenches.
Bathymetry Charts
How do we map the oceans?
Using remote technologies-underwater and with satellites

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports

NOVEMBER

UNIT #5. The Water Planet
Chapter 17. Climate and the Ocean

Layers of the Atmosphere
Composition of atmosphere
Air Masses
Circulation of air around the Earth
Atmosphere and Ocean Interaction
Coriolis Effect
Air Density & Pressure
Water Cycle, water vapor, humidity
Prevailing winds
Hurricane and cyclone formation.
Weather vs Climate
Interaction of atmosphere and ocean
Oceans help support life on Earth
Energy in Earth's Spheres
Law of Conservation of Energy
Environmental Health Hazards
Climate and Global Warming
The Effects of Climate change
Ocean Currents and Climate, El Nino-La Nina
The Greenhouse Effect
The Ozone Layer and UV radiation

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports

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DECEMBER

UNIT #6 Energy in the Ocean
Chapter 18. Temperature and Pressure

Effects of Pressure and depth
Aquatic adaptions.
Temperature variations.
Salinity of water and its properties and effects

Chapter 19 Lights and Sounds of the Sea

Light and water
How sound travels
Water Color
Seasons and Earths Tilt and Rotation.
Solar Radiation
Differential Heating
Specific Heat
Land and Sea Breezes

Chapter 20. Tides, Waves and Currents

Ocean Currents – Surface, subsurface
El Nino-La Nina Southern Oscillation
Gulf Stream
Global Conveyor Belt
Upwelling
Sea Surface Temperatures
Temperate Seas-Warm Seas-Polar Seas
Wave basic structure & formation
Wind and waves, Rip currents, Longshore drift
Power of waves
Lunar Influence – highs and lows
Earth's Tilt-Seasons-Solar Energy
Understanding Tide Tables
Tides and marine life

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports

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JANUARY

UNIT #7 Marine Ecology and Conservation

Chapter 21. Marine Environments.

Describe the basis for the coral-reef ecosystem.
Describe the types of coral reefs, namely fringing reefs, barrier reefs, and atolls.
Types of Ocean Ecosystems Overview: Rocky Shores, Sandy Beaches
Kelp Forests, Mangroves and Swamps, Types of Estuaries, and Salt Marshes, Mudflats
Explore the unique environmental characteristics of the abyssal sea floor.
Discuss types and sources of sediments of the abyssal sea floor
Explain temperature, pressure, and oxygen concentration of the abyssal sea floor.
Summarize mechanisms of oxygen and energy transfer to the deep sea.
Review deep-sea species diversity and feeding strategies commonly employed.
Explore the characteristics of deep-sea hot springs and other densely populated animal communities dependent on chemosynthetic bacteria for primary production.

Chapter 22. Interdependence in the Sea

Natural Cycles
Biogeochemical cycles
Feeding relationships, food chains, food webs
Symbiotic Relationships
Coevolution
Mutualism, Parasitism and Commensalism
Succession
Primary productivity in the ocean.
Carbon Cycle-Nutrients cycling
Producers, consumers, decomposers.
Photosynthesis in the sea-zooplankton, phytoplankton
Algal Blooms
Describe the vertical migration of zooplankton.
Species relationships in the various stratifications and habitats of the ocean.
Examine the details of how migration integrates feeding and reproduction in species.
Examine oceanic migration patterns in an effort to deduce mechanisms of orientation and navigation

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports
Mid-Term Test & Benchmark

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February

UNIT #7 Marine Ecology and Conservation.

Chapter 23. Pollution in the Ocean.

Marine Debris
Great Pacific Garbage Patch
Pollutants-Nutrients, oil, chemicals
Types of Water Pollution and Preventing Ocean Pollution
How water pollution affects ecosystems
Cleaning up water pollution – Preventing Ocean Pollution
Oil Spills
Most Dangerous oil spills of all time-so far!
Oil and Marine life and sea birds.
Bioremediation
Cleaning oil spills
Types of Water Pollution and Preventing Ocean Pollution
How water pollution affects ecosystems
Cleaning up water pollution – Preventing Ocean Pollution.

UNIT #2 Basic Life Forms in the Sea

Chapter 4. Unicellular Marine Organisms
Bacteria-Diatoms-Dinoflagellates

Chapter 5. Marine Algae and Plants
Grasses, mangroves, beach plants marine algae

Chapter 6. Simple Marine Animals
Plankton, Zooplankton, Sponges

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports.

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March

UNIT #3 Marine Invertebrates

Chapter 7. Cidarians

Phyla of Invertebrates
Jellyfish, Corals, Sea Anemones
Structure and functioning of invertebrates.
Squid, Octopus and other invertebrates

Chapter 8. Marine Worms

Flatworms, Giant Tube worms

Chapter 9. Mollusk**s**

Bi-valves (clams) Cephalopods, Gastropods

Chapter 10. Crustaceans

Lobsters, crabs, shrimp, barnacles

Chapter 11. Echinoderms

Sea Stars, Sand Dollars

April

UNIT #4 Marine Vertebrates

Chapter 12. Marine Fishes

Fish Gills - Countercurrent Flow and Gas Exchange
Investigating the structure and functions of fish
Fishes and Niches
Marine Carnivores
Sharks as Predators
Sharks, Rays, and Chimeras

Chapter 13. Marine Reptiles and Sea Birds

Marine Reptiles
Diversity and Reproduction
Range of Reptiles and sea Birds
Marine Birds
Sea Turtles
Amphibians

Chapter 14. Marine Mammals

Diversity and Reproduction
Species of Marine Mammals
Marine Mammal Carnivores
Cetaceans
Migration range, habits and feeding
Tracking mammals
Sounds and navigational ability – can they speak and understand?

Assessments:
Chapter Test, Unit Quiz, Classwork/Homework, Lab & reports

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May-June

UNIT#7

Chapter 24. Conservation of Resources.

Biodiversity in the Ocean
Biological Classification
Tree of Life – Taxonomy
Unity of Life
Census of Marine Life
IUCN Red List
CITES – Endangered Species

Humans and Coastlines

Barrier Island
Modeling Wetlands
Beach Replenishment
Should we build on the Beaches?
Effects of storms and ocean current on shorelines
History of Whaling
Atlantic Bluefin Tuna
Impact of trade in marine ornamental species by hobbyists.
Modern fishing and whaling practices
Overfishing-"Fishing Down the Food Chain"
Fish Farming-Sustainable Practices.

Assessments:
Chapter Test, Unit Quiz, Classwork/Homework, Lab & reports
Marine Protected Areas (MPA's)
Marine Sanctuaries
Develop and express a sense of responsibility and stewardship toward the marine environment.
National and International Cooperation for Resource Management

Assessments:
Chapter Tests, Unit Quiz, Classwork/Homework, Projects, Lab & reports
FINAL EXAM & Benchmark

Total Instructional Time	**33 Weeks (165 days)**
Finals, PARCC, PSAT, SAT, Pre/Post Tests, Benchmarks, End of Term Biology Test	**3 Weeks (15 days)**
Totals	**36 Weeks (180 days)**

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Marine Science Honors

9th 10th 11th & 12th Grades

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

Curriculum: Steve Nagiewicz, Science Teacher

(August 2018 DRAFT)

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XXXIV. **OVERVIEW**

Marine Science is an interdisciplinary science course that will provide students with an awareness of the basic concepts of Physical Sciences and Life Sciences to include; comprising of archaeology, astronomy, biology, chemistry, climatology, geography, geology, hydrology, meteorology and physics. Paleoceanography studies the history of the oceans in the geologic past and combines them with principles of social, economic, and moral ethics.

The course allows each student to analyze and decide current issues concerning management of the oceans in order to maintain or improve the quality of life on earth. This course is designed to provide students with the scientific principles, concepts and methodologies required to understand the interrelationships of the natural world, to identify and analyze ocean-related issues and environmental problems (natural and human-made), to evaluate the relative risks associated with these current problems and to examine for resolving and/or preventing them. This Honors course meets for five single periods a week and include one additional period/day which will be a laboratory demonstration of a key concept.

XXXV. **RATIONALE**

Our Oceans comprise over 70% of the Earth's surface and contain an intricately balanced mixture of atmosphere and sea to regulate climate, produce food, and provide travel. Various environmental problems and ecological limits are real and will be affecting all of us in various ways for the rest of our lives. To successfully meet these challenges, it is necessary that we, as individuals and as a society, fully understand the nature of our interactions with our oceans and the impact humans have on our oceans, atmosphere and the life contain within. The overall objective of this course is to describe the importance of our marine environment and the constraints which humankind confronts and to show the courses of action which may be taken in order to cope successfully with them.

XXXVI. TEXTBOOK

Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed Meets Next Generation Science Standards (NGSS) and Common Core State Standards (CCCS)

Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed offers data driven investigations, meaningful context-based activities and lessons that seamlessly integrate Science, Technology, Engineering and Mathematics (STEM) for the deeper conceptual understanding valued by the Next Generation Science Standards (NGSS).

NGSS focuses the developmental progression through Disciplinary Core Ideas on a core understanding of content and the application of knowledge in real-world scenarios. From cover to cover, **Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed** is built on the integrated STEM philosophy that drives NGSS.

Lessons are thoughtfully sequenced to build strong, conceptual understanding of the ocean and the Earth as a system, and make real-life data driven connections that are interesting and meaningful to today's high school students.

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Foundations of NGSS and Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed. Nature of Science (NOS) A deep understanding of the NOS is essential to a strong science education and highly valued in Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed. The text directly addresses important NOS terminology and contextualizes examples of how science is conducted in everyday life. The course highlights the tenets of the NOS in each lesson to show the educator exactly how the content helps students learn and apply principles, to ensure that NOS is a consistent, underlying theme.

Science and Engineering Practices

Inquiry as a scientific practice is central to the development of Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed. The application of concepts to socio-scientific issues which inspire meaningful discourse and justification of ideas occurs throughout exciting investigations of marine ecosystems. Students engage in an exploration of the threats to marine life and the responsibility of humans to protect the ocean and its vast resources. They employ the Engineering Design Process, which incorporates NGSS's eight practices of science and engineering to investigate point source pollution and design ways to effectively clean up oil spills. Throughout the course, students demonstrate a deep understanding of scientific concepts through the application of engineering.

Crosscutting Concepts

The field of Marine Science is truly interdisciplinary, void of conceptual boundaries. Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed includes exciting applications of STEM that demonstrate bridging concepts across disciplines in the exciting context of the ocean. Examples of some topics covered in Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Ed that demonstrate NGSS Crosscutting Concepts:

1. Patterns.
   Classification of marine organisms; structure and function; biological evolution; properties of matter; properties of water
2. Cause and effect: Mechanism and explanation
   Scientific investigations; engineering practices; impacts of coastal development; symbiotic relationships between species
3. Scale, proportion, and quantity.
   Population dynamics
4. Systems and system models.
   Using models to demonstrate various concepts: 1) transfer of energy; 2) using engineering design to address pollution challenges; 3) studying human induced habitat destruction; 4) identifying solutions
5. Energy and matter: Flows, cycles, and conservation.
   Cycling of energy and matter; biogeochemical cycles; conservation of energy
6. Structure and function.
   Study of marine animals; adaptations to marine environments
7. Stability and change.
   Population dynamics, coevolution; natural selection

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XXXVII. **STANDARDS**

The following list identifies the cross-referencing of the NextGen Science Standards of 2017-18 and the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (January 2017).

Next Gen Science Standards (NGSS)

Lesson Title	**NGSS High Disciplinary Core Idea code**
Diving into Ocean Ecosystems	HS-LS2-3
Water on Earth	HS-ESS2-5, HS-PS1-5, HS-PS1-1
More about Water	HS-ESS2-5, HS-PS1-2, HS-PS1-3
The Ocean over time	HS-ESS3-1, HS-ESS3-4
Migrations in the Sea	HS-PS4-5, HS-PS4-2
Explore the Sea Floor	HS-PS4-5
The Formation of the Ocean	HS-ESS1-5 , HS-ESS2-1 , HS-ESS2-1, HS-ESS2-3,
Seasons of Change	HS-ESS2-1, HS-PS4-3, HS-ESS2-4
The Sea Surface	HS-PS3-2, HS-ESS2-4, HS-ESS2-5
Energy and the Ocean	HS-PS3-1, HS-PS3-2, HS-PS3-4
Weather, Climate and the Ocean	HS-ESS2-2
Voyage to the Deep	HS-ESS2-2
Photosynthesis in the Ocean	HS-LS1-5, HS-LS2-5, HS-ESS2-4, HS-ESS2-5.
Biodiversity in the Ocean	HS-LS1-1, HS-LS1-2
Marine Populations	HS-LS1-4, HS-LS2-1, HS-LS2-2, HS-LS2-6, HS-LS2-8, HS-ESS2-7, HS-LS4-1, HS-LS4-2, HS-LS4-3, HS-LS4-4, HS-LS4-5, HS-LS3-3, HS-LS2-2, HS-LS2-8
Food Webs in Action	HS-ESS2-6, HS-LS1-7, HS-LS2-3, HS-LS2-4
Introduction to Marine Invertebrates	HS-LS1-2
Biology of Fishes	HS-LS4-3, HS-LS1-1
Marine Reptiles and birds	HS-LS4-3
Marine Mammals	HS-LS1-4, HS-LS2-8
Relationships in the Sea	HS-LS2-8
The Ocean's Waves	HS-PS4-1
A Time for Tides	HS-ESS1-4
Animal Needs and Animal Tracking	HS-PS4-2
Student Expert Research	HS-PS4-4
Student Expert Analysis	HS-PS4-4
Which Way to the Sea	HS-ESS2-1, HS-ESS2-2, HS-ESS1-6, HS-ESS2-7
Nonpoint Source Pollution	HS-LS4-6
Point source oil pollution	HS-ESS3-2, HS-ESS3-4, HS-ESS3-6, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-LS4-6
Humans and Coastlines	HS-ESS3-1, HS-LS2-7
The Ocean's Resources	HS-ESS3-1
Changing Climate	HS-ESS2-2, HS-ESS2-4, HS-ESS3-5, HS-ESS2-7
Protecting Marine Habitats	HS-ESS3-6, HS-LS2-7

**** Lessons and curriculum standards based upon recommended textbook**

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Science - NJ 2009 Core Curriculum Content Standards

5.1 Science Practices: All students will understand that science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.

5.1.A Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world.

5.1.A.5.1.12.A.1 Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles.

CPI: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.

5.1.A.5.1.12.A.2 Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations.

CPI: Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.

5.1.A.5.1.12.A.3 Revisions of predictions and explanations are based on systematic observations, accurate measurements, and structured data/evidence.

CPI: Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.

5.1.B Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims.

5.1.B.5.1.12.B.1 Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.

CPI: Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data.

5.1.B.5.1.12.B.2 Mathematical tools and technology are used to gather, analyze, and communicate results.

CPI: Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.

5.1.B.5.1.12.B.3 Empirical evidence is used to construct and defend arguments.

CPI: Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.

5.1.B.5.1.12.B.4 Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.

CPI: Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.

5.1.C Reflect on Scientific Knowledge: Scientific knowledge builds on itself over time.

5.1.C.5.1.12.C.1 Refinement of understandings, explanations, and models occurs as new evidence is incorporated.

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CPI: Reflect on and revise understandings as new evidence emerges.

5.1.C.5.1.12.C.2 Data and refined models are used to revise predictions and explanations.

CPI: Use data representations and new models to revise predictions and explanations

5.1.C.5.1.12.C.3 Science is a practice in which an established body of knowledge is continually revised, refined, and extended as new evidence emerges.

CPI: Consider alternative theories to interpret and evaluate evidence-based arguments.

5.1.D Participate Productively in Science: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms.

5.1.D.5.1.12.D.1 Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.

CPI: Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.

5.1.D.5.1.12.D.2 Science involves using language, both oral and written, as a tool for making thinking public.

CPI: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.

5.1.D.5.1.12.D.3 Ensure that instruments and specimens are properly cared for and that animals, when used, are treated humanely, responsibly, and ethically.

CPI: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.

5.2 Physical Science: All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

5.2.A. Properties of Matter: All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia.

5.2.12.A.6 Acids and bases are important in numerous chemical processes that occur around us, from industrial to biological processes, from the laboratory to the environment.

CPI: Relate the pH scale to the concentrations of various acids and bases.

5.2.B. Changes in Matter: Substances can undergo physical or chemical changes to form new substances. Each change involves energy.

5.2.12.B.2 A large number of important reactions involve the transfer of either electrons or hydrogen ions between reacting ions, molecules, or atoms. In other chemical reactions, atoms interact with one another by sharing electrons to create a bond.

CPI: Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel.

5.3 Life Science: All students will understand that life science principles are powerful conceptual tools for making sense of the complexity, diversity, and interconnectedness of life on Earth. Order in natural systems arises in accordance with rules that govern the physical world, and the order of natural systems can be modeled and predicted through the use of mathematics.

5.3.B. Matter and Energy Transformations: Food is required for energy and building cellular materials. Organisms in an ecosystem have different ways of obtaining food, and some organisms obtain their food directly from other organisms.

5.3.12.B.3 Continual input of energy from sunlight keeps matter and energy flowing through

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ecosystems.

CPI: Predict what would happen to an ecosystem if an energy source was removed.

5.3.12.B.5 In both plant and animal cells, sugar is a source of energy and can be used to make other carbon-containing (organic) molecules.

CPI: Investigate and describe the complementary relationship (cycling of matter and flow of energy) between photosynthesis and cellular respiration

5.3.12.B.6 All organisms must break the high-energy chemical bonds in food molecules during cellular respiration to obtain the energy needed for life processes.

CPI: Explain how the process of cellular respiration is similar to the burning of fossil fuels

5.3.C. Interdependence: All animals and most plants depend on both other organisms and their environment to meet their basic needs.

5.3.12.C.1 Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms.

CPI: Analyze the interrelationships and interdependencies among different organisms, and explain how these relationships contribute to the stability of the ecosystem.

5.3.12.C.2 Stability in an ecosystem can be disrupted by natural or human interactions.

CPI: Model how natural and human-made changes in the environment will affect individual organisms and the dynamics of populations.

5.3.E. Evolution and Diversity: Sometimes, differences between organisms of the same kind provide advantages for surviving and reproducing in different environments. These selective differences may lead to dramatic changes in characteristics of organisms in a population over extremely long periods of time.

5.3.12.E.2 Molecular evidence (e.g., DNA, protein structures, etc.) substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched.

CPI: Estimate how closely related species are, based on scientific evidence. The principles of evolution (including natural selection and common descent) provide a scientific explanation for the history of life on Earth as evidenced in the fossil record and in the similarities that exist within the diversity of existing organisms

5.4 Earth Systems Science: All students will understand that Earth operates as a set of complex, dynamic, and interconnected systems, and is a part of the all-encompassing system of the universe.

5.4.B. History of Earth: From the time that Earth formed from a nebula 4.6 billion years ago, it has been evolving as a result of geologic, biological, physical, and chemical processes.

5.4.12.B.1 The evolution of life caused dramatic changes in the composition of Earth's atmosphere, which did not originally contain oxygen gas.

CPI: Trace the evolution of our atmosphere and relate the changes in rock types and life forms to the evolving atmosphere.

5.4.C. Properties of Earth Materials: Earth’s composition is unique, is related to the origin of our solar system, and provides us with the raw resources needed to sustain life.

5.4.12.C.1 Soils are at the interface of the Earth systems, linking together the biosphere, geosphere, atmosphere, and hydrosphere.

CPI: Model the interrelationships among the spheres in the Earth systems by creating a flow chart.

5.4.12.C.2 The chemical and physical properties of the vertical structure of the atmosphere support life on Earth.

CPI: Analyze the vertical structure of Earth's atmosphere, and account for the global, regional, and local variations of these characteristics and their impact on life.

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5.4.D. Tectonics: The theory of plate tectonics provides a framework for understanding the dynamic processes within and on Earth.

5.4.12.D.1 Convection currents in the upper mantle drive plate motion. Plates are pushed apart at spreading zones and pulled down into the crust at subduction zones.

CPI: Explain the mechanisms for plate motions using earthquake data, mathematics, and conceptual models.

5.4.12.D.2 Evidence from lava flows and ocean-floor rocks shows that Earth's magnetic field reverses (North - South) over geologic time.

CPI: Calculate the average rate of seafloor spreading using archived geomagnetic-reversals data.

5.4.E. Energy in Earth Systems: Internal and external sources of energy drive Earth systems.

5.4.12.E.1 The Sun is the major external source of energy for Earth's global energy budget.

CPI: Model and explain the physical science principles that account for the global energy budget.

5.4.12.E.2 Earth systems have internal and external sources of energy, both of which create heat.

CPI: Predict what the impact on biogeochemical systems would be if there were an increase or decrease in internal and external energy.

5.4.F. Climate and Weather: Earth's weather and climate systems are the result of complex interactions between land, ocean, ice, and atmosphere.

5.4.12.F.1 Global climate differences result from the uneven heating of Earth's surface by the Sun. Seasonal climate variations are due to the tilt of Earth's axis with respect to the plane of Earth's nearly circular orbit around the Sun.

CPI: Explain that it is warmer in summer and colder in winter for people in New Jersey because the intensity of sunlight is greater and the days are longer in summer than in winter. Connect these seasonal changes in sunlight to the tilt of Earth's axis with respect to the plane of its orbit around the Sun.

5.4.12.F.2 Climate is determined by energy transfer from the Sun at and near Earth's surface. This energy transfer is influenced by dynamic processes, such as cloud cover and Earth's rotation, as well as static conditions, such as proximity to mountain ranges and the ocean. Human activities, such as the burning of fossil fuels, also affect the global climate.

CPI: Explain how the climate in regions throughout the world is affected by seasonal weather patterns, as well as other factors, such as the addition of greenhouse gases to the atmosphere and proximity to mountain ranges and to the ocean.

5.4.12.F.3 Earth's radiation budget varies globally, but is balanced. Earth's hydrologic cycle is complex and varies globally, regionally, and locally.

CPI: Explain variations in the global energy budget and hydrologic cycle at the local, regional, and global scales.

5.4.G. Biogeochemical Cycles: The biogeochemical cycles in the Earth systems include the flow of microscopic and macroscopic resources from one reservoir in the hydrosphere, geosphere, atmosphere, or biosphere to another, are driven by Earth's internal and external sources of energy, and are impacted by human activity.

5.4.12.G.1 Natural and human-made chemicals circulate with water in the hydrologic cycle.

CPI: Analyze and explain the sources and impact of a specific industry on a large body of water (e.g., Delaware or Chesapeake Bay)

5.4.12.G.2 Natural ecosystems provide an array of basic functions that affect humans. These

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functions include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients.

CPI: Explain the unintended consequences of harvesting natural resources from an ecosystem.

5.4.12.G.3 Movement of matter through Earth's system is driven by Earth's internal and external sources of energy and results in changes in the physical and chemical properties of the matter.

CPI: Demonstrate, using models, how internal and external sources of energy drive the hydrologic, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles.

5.4.12.G.4 Natural and human activities impact the cycling of matter and the flow of energy through ecosystem.

CPI: Compare over time the impact of human activity on the cycling of matter and energy through ecosystems.

5.4.12.G.5 Human activities have changed Earth's land, oceans, and atmosphere, as well as its populations of plant and animal species.

CPI: Assess (using maps, local planning documents, and historical records) how the natural environment has changed since humans have inhabited the region.

5.4.12.G.6 Scientific, economic, and other data can assist in assessing environmental risks and benefits associated with societal activity.

CPI: Assess (using scientific, economic, and other data) the potential environmental impact of large-scale adoption of emerging technologies (e.g., wind farming, harnessing geothermal energy)

5.4.12.G.7 Earth is a system in which chemical elements exist in fixed amounts and move through the solid Earth, oceans, atmosphere, and living things as part of geochemical cycles.

CPI: Relate information to detailed models of the hydrologic, carbon, nitrogen, phosphorus, sulfur, and oxygen cycles, identifying major sources, sinks, fluxes, and residence times

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STUDENT OUTCOMES

A. KNOWLEDGE (Information and Concepts)
The students will (verbally or in writing):

1. Define, in writing/discussion, the concept of our ocean ecosystem including identifying abiotic and biotic components, explaining the importance of climatology and our weather, deep ocean exploration as well as sustainable fisheries, protection of endangered animals.
2. Determine, from evidence given, whether ocean ecosystems are stable or in danger of collapse.
3. Describe, in writing/discussion/project, the key chemical concepts and processes responsible for maintaining ocean environmental stability. For example, sustainable fisheries and protection of endangered species
4. Explain, in writing/discussion/project, the dynamic balance that exists among the components that make up ocean.
5. Discuss, in writing/discussion, the hydrologic cycle and how it helps connect all ecosystems together and to describe the effect that man has had on it.
6. Describe the impact of domestic pollution and wastes on the ocean and the existence of humankind.
7. Summarize and state in writing, several key concepts presented in news articles as they relate to marine science research, advocacy and ethics.
8. Explain, in writing, the limits to growth with respect to living with a finite quantity of resources.
9. Summarize, in writing/discussion/project, as many diverse opinions and scientific principles that need to be researched in order to attempt to answer questions such as "Can ocean pollution be controlled?" and "What will future marine mammals population decreases do to the ocean environment?"
10. Recognize, in writing/discussion, current and past leaders of marine science and their contributions.

B. ATTITUDES
The student will:

1. Develop an appreciation for the study of marine science and how it relates to his/her everyday life.
2. Research and investigate possible careers in marine science
3. Recognize the impact of marine science on every aspect of daily life.

C. SKILLS AND BEHAVIOR
The student will:

1. Demonstrate good problem-solving techniques
2. Write essays on specific topics in marine science demonstrating comprehension of a given topic, i.e. the historical development of the subject
3. Demonstrate effective listening and note taking skills in lecture and discussion situations
4. Demonstrate proper and safe use of laboratory equipment and chemicals during

experiments
5. Use the scientific method in solving laboratory based problems and writing reports based on their solutions
6. Demonstrate in class discussion and in writing a comprehensive knowledge of marine science
7. Work cooperatively in small groups to solve problems or perform experiments
8. Design and interpret graphs using data
9. Use spreadsheet and graphing software to report results of laboratory investigations
10. Design and produce presentations using Power Point presentation software
11. Set up and perform experiments using computer interfaced sensors to collect data
12. Utilize Internet search engines to locate environmental science related websites for research and review

XXXVIII. ACCOMMODATIONS AND MODIFICATIONS

The NextGen Science Standards (NGSS) and the New Jersey Core Curriculum Content Standards (NJCCCS) reflect concepts that all children need to grow intellectually, socially and emotionally. Goals and objectives for all students, no matter how significant their learning challenges, should be related to the NGSS & NJCCCS and associated cumulative progress indicators. Working within the framework of the standards, using accommodations and modifications as needed, will prepare students to proficiently participate in the *Partnership for Assessment of Readiness for College and Careers* (PARCC) College Board (PSAT) and (SAT) Assessments and New Jersey Assessment of Skills and Knowledge (NJ ASK) or the Alternative Proficiency Assessment (APA).

The Special Education Department will follow the district's general education curricula, reflecting the following New Jersey Core Curriculum Content Standards (NJCCCS). These standards and related curriculum frameworks are the focus of curriculum and instruction for all students.

Curriculum and instructional adaptations may be required in order to provide meaningful assessment and exposure to the material based on the content standards. "The adaptations are not intended to compromise the content standards. Instead, adaptations provide students with disabilities the opportunity to maximize their strengths and compensate for their learning differences." (**New Jersey Department of Education** Cross-Content Framework, p 7.1, Appendix B)

Accommodations refer to the actual teaching supports and services that the student may require to successfully demonstrate learning. Accommodations should not change expectations to the curriculum grade levels. Accommodations may include but are not limited to: taped books, math charts, additional time, oral test, oral reports, preferred seating, study carrel, amplified system, braille writer, adapted keyboard, specialized software, etc.

Modifications refer to changes made to curriculum expectations in order to meet the needs of the student. Modifications are made when the expectations are beyond the student's level of ability. Modifications may be minimal or very complex depending on the student performance. Modifications must be clearly acknowledged in the IEP. Modifications may include but are not limited to: second language exemptions, withdrawal for specific skills, include student in same

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activity but individualize the expectations and materials, student is involved in same theme/unit but provide different task and expectations, etc.

V. INSTRUCTIONAL STRATEGIES

The following strategies/activities will be used:

NOTE: The suggested activities provided in this document are ideas for the teacher. If the teacher chooses to develop his/her own activity, *it must be of equal or better quality and at the same or higher cognitive levels.*

- Audio visual media
- Charts, handouts, graphs
- Class & individual assignments
- Cooperative activities
- Critical thinking:
  - Decision making
  - Compare & contrast
  - Reliable sources
  - Causal explanation
  - Prediction
- Debates & panel discussion
- Demonstrations (teacher/student led)
- Direct instruction
- Discussion (teacher/student led)
- Drill practice
- Extra credit project or presentation
- Homework
- Investigation
- Laboratory experiment
- Lecture
- Library and resource documents
- Oral reading
- Periodicals
- Questioning techniques
- Research paper
- Reviews
- Self-instructional instruments
- Textbook
- Textbook supplements
- Tutoring (peer & teacher)

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VI. EVALUATION

NOTE: Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.

Assessments may include

DERIVED ASSESSMENT *inferred from student's ability to respond to items on paper*.

- Tests
- Quizzes
- Homework
- Pre and Post Quarterly assessments

AUTHENTIC ASSESSMENT *based on behavior, product, or outcome*.

- Class participation
- Teacher observation
- Infusion exercises
- Portfolios

PERFORMANCE ASSESSMENT *authentic assessment specific to environmental science*.

- Laboratory

IX. REQUIRED RESOURCES

Student resources:

1. **Textbook:** *Marine Science - Marine Biology & Oceanography by Thomas Greene 3rd Edition, AMSCO.*
2. Technology: Chromebook cart. Google and Google Documents/Drive, EdConnect, and Internet Resources, textbook/publisher web resources.
3. Addition resources:
4. Textbooks

   Marine Biology Coloring Book, 2nd Edition by Thomas Niesen, 2000.

   Introduction to the Biology of Marine Life. 8th Edition by James Sumich. 2004

   Marine Science: The Dynamic Ocean, Meghan Marrero, 2012.

   Reference materials
   Audio-visual materials, DVD's
   Computer software
   NBC Learn
   YouTube videos
   Media center internet reference and data search
   Alternative assessment activities

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X. SCOPE AND SEQUENCE

UNIT 1 – Introduction to Marine Science.

SEPTEMBER

Science Basics Review

Chapter 1. Exploring the Oceans.
Understand the major physiographic provinces of the marine environment.
Diversity and distribution of marine organisms
Describe the basis for the coral-reef ecosystem.
Understanding geography and bathymetry.
Describe the types of coral reefs, namely fringing reefs, barrier reefs, and atolls.
Types of Ocean Ecosystems Overview: Rocky Shores, Sandy Beaches
Kelp Forests, Mangroves and Swamps, Types of Estuaries, and Salt Marshes, Mudflats

Chapter 2. Science as Inquiry**.**
Scientific Method, Scientific Measurements, science project and research paper
Steps of the Scientific Method
Science Math, Measurements & Statistics
Reading & Understanding Graphs
Using geography, maps & charts
Lab Procedures, Safety and Reports
Solving scientific problems

Chapter 3 Marine Science and Technology
Types of Ocean Technology and Science and how data is used, Scuba Diving,
Oceans and people, careers in Marine Science.
History of the Oceans-Timeline
Shipwrecks and Marine Archaeology
Ocean Technologies
Using technology to explore the deep ocean.
Scuba Diving, submarines, robotics.
Sea Perch ROV's

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports
Benchmark Pre-Test

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OCTOBER

UNIT #5. The Water Planet

Chapter 15. The World of Water

Chemical and physical properties of the water and seawater
Water-the three States of Matter
Density
Floating and water molecules
Color and visibility
Chemical and physical properties of the water and seawater
Water is the Universal Solvent
Effects of Pressure and depth
Cohesion
Salinity of water and its properties and effects

Chapter 16. Geology and the Ocean.

Formation of the ocean
The theory of plate tectonics
Three types of crustal movement
Volcanoes, Earthquakes and Tsunamis
Dangerous Tsunami's
Evidence of seafloor spreading
Black Smoking Vents
Deepsea trenches Understand the geography of the ocean
Types of geography on the seafloor-Ocean Basin, guyots, mountains, trenches.
Bathymetry Charts
How do we map the oceans?
Using remote technologies-underwater and with satellites

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports

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NOVEMBER

UNIT #5. The Water Planet
Chapter 17. Climate and the Ocean

Layers of the Atmosphere
Composition of atmosphere
Air Masses
Circulation of air around the Earth
Atmosphere and Ocean Interaction
Coriolis Effect
Air Density & Pressure
Water Cycle, water vapor, humidity
Prevailing winds
Hurricane and cyclone formation.
Weather vs Climate
Interaction of atmosphere and ocean
Oceans help support life on Earth
Energy in Earth's Spheres
Law of Conservation of Energy
Environmental Health Hazards
Climate and Global Warming
The Effects of Climate change
Ocean Currents and Climate, El Nino-La Nina
The Greenhouse Effect
The Ozone Layer and UV radiation

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports

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DECEMBER

UNIT #6 Energy in the Ocean
Chapter 18. Temperature and Pressure
Effects of Pressure and depth
Aquatic adaptions.
Temperature variations.
Salinity of water and its properties and effects

Chapter 19 Lights and Sounds of the Sea
Light and water
How sound travels
Water Color
Seasons and Earths Tilt and Rotation.
Solar Radiation
Differential Heating
Specific Heat
Land and Sea Breezes
Chapter 20. Tides, Waves and Currents
Ocean Currents – Surface, subsurface
El Nino-La Nina Southern Oscillation
Gulf Stream
Global Conveyor Belt
Upwelling
Sea Surface Temperatures
Temperate Seas-Warm Seas-Polar Seas
Wave basic structure & formation
Wind and waves, Rip currents, Longshore drift
Power of waves
Lunar Influence – highs and lows
Earth's Tilt-Seasons-Solar Energy
Understanding Tide Tables
Tides and marine life

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports

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JANUARY

UNIT #7 Marine Ecology and Conservation

Chapter 21. Marine Environments.

Describe the basis for the coral-reef ecosystem.
Describe the types of coral reefs, namely fringing reefs, barrier reefs, and atolls.
Types of Ocean Ecosystems Overview: Rocky Shores, Sandy Beaches
Kelp Forests, Mangroves and Swamps, Types of Estuaries, and Salt Marshes, Mudflats
Explore the unique environmental characteristics of the abyssal sea floor.
Discuss types and sources of sediments of the abyssal sea floor
Explain temperature, pressure, and oxygen concentration of the abyssal sea floor.
Summarize mechanisms of oxygen and energy transfer to the deep sea.
Review deep-sea species diversity and feeding strategies commonly employed.
Explore the characteristics of deep-sea hot springs and other densely populated animal communities dependent on chemosynthetic bacteria for primary production.

Chapter 22. Interdependence in the Sea

Natural Cycles
Biogeochemical cycles
Feeding relationships, food chains, food webs
Symbiotic Relationships
Coevolution
Mutualism, Parasitism and Commensalism
Succession
Primary productivity in the ocean.
Carbon Cycle-Nutrients cycling
Producers, consumers, decomposers.
Photosynthesis in the sea-zooplankton, phytoplankton
Algal Blooms
Describe the vertical migration of zooplankton.
Species relationships in the various stratifications and habitats of the ocean.
Examine the details of how migration integrates feeding and reproduction in species.
Examine oceanic migration patterns in an effort to deduce mechanisms of orientation and navigation

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports
Mid-Term Test & Benchmark

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February

UNIT #7 Marine Ecology and Conservation.

Chapter 23. Pollution in the Ocean.

Marine Debris
Great Pacific Garbage Patch
Pollutants-Nutrients, oil, chemicals
Types of Water Pollution and Preventing Ocean Pollution
How water pollution affects ecosystems
Cleaning up water pollution – Preventing Ocean Pollution
Oil Spills
Most Dangerous oil spills of all time-so far!
Oil and Marine life and sea birds.
Bioremediation
Cleaning oil spills
Types of Water Pollution and Preventing Ocean Pollution
How water pollution affects ecosystems
Cleaning up water pollution – Preventing Ocean Pollution.

UNIT #2 Basic Life Forms in the Sea

Chapter 4. Unicellular Marine Organisms
Bacteria-Diatoms-Dinoflagellates

Chapter 5. Marine Algae and Plants
Grasses, mangroves, beach plants marine algae

Chapter 6. Simple Marine Animals
Plankton, Zooplankton, Sponges

Assessments:
Chapter Quiz Unit Test, Classwork/Homework, Projects, Lab & reports.

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March

UNIT #3 Marine Invertebrates

Chapter 7. Cnidarians
Phyla of Invertebrates
Jellyfish, Corals, Sea Anemones
Structure and functioning of invertebrates.
Squid, Octopus and other invertebrates

Chapter 8. Marine Worms
Flatworms, Giant Tube worms

Chapter 9. Mollusk**s**
Bi-valves (clams) Cephalopods, Gastropds

Chapter 10. Crustaceans
Lobsters, crabs, shrimp, barnacles

Chapter 11. Echinoderms
Sea Stars, Sand Dollars

April

UNIT #4 Marine Vertebrates

Chapter 12. Marine Fishes
Fish Gills - Countercurrent Flow and Gas Exchange
Investigating the structure and functions of fish
Fishes and Niches
Marine Carnivores
Sharks as Predators
Sharks, Rays, and Chimeras

Chapter 13. Marine Reptiles and Sea Birds
Marine Reptiles
Diversity and Reproduction
Range of Reptiles and sea Birds
Marine Birds
Sea Turtles
Amphibians

Chapter 14. Marine Mammals
Diversity and Reproduction
Species of Marine Mammals
Marine Mammal Carnivores
Cetaceans
Migration range, habits and feeding
Tracking mammals
Sounds and navigational ability – can they speak and understand?

Assessments:
Chapter Test, Unit Quiz, Classwork/Homework, Lab & reports

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May-June

UNIT#7

Chapter 24. Conservation of Resources.
Biodiversity in the Ocean
Biological Classification
Tree of Life – Taxonomy
Unity of Life
Census of Marine Life
IUCN Red List
CITES – Endangered Species
Humans and Coastlines
Barrier Island
Modeling Wetlands
Beach Replenishment
Should we build on the Beaches?
Effects of storms and ocean current on shorelines
History of Whaling
Atlantic Bluefin Tuna
Impact of trade in marine ornamental species by hobbyists.
Modern fishing and whaling practices
Overfishing-“Fishing Down the Food Chain”
Fish Farming-Sustainable Practices.

Assessments:
Chapter Test, Unit Quiz, Classwork/Homework, Lab & reports
Marine Protected Areas (MPA’s)
Marine Sanctuaries
Develop and express a sense of responsibility and stewardship toward the marine environment.
National and International Cooperation for Resource Management

Assessments:
Chapter Tests, Unit Quiz, Classwork/Homework, Projects, Lab & reports
FINAL EXAM & Benchmark

Total Instructional Time	**33 Weeks (165 days)**
Finals, PARCC, PSAT, SAT, Pre/Post Tests, Benchmarks, End of Term Biology Test	**3 Weeks (15 days)**
Totals	**36 Weeks (180 days)**

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Earth Science

Grades 9th through 12th

DRAFT

Prepared by
Stephen Nagiewicz, Teacher

Curriculum Task Force August, 2018

Atlantic City Public Schools
1300 Atlantic Avenue, Atlantic City, NJ 08401

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(Revised August 2018)

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XXXIX. **OVERVIEW**

The Earth Science curriculum is a contemporary, interdisciplinary approach to the study of earth and its environment. The program incorporates the latest thinking and theories of prominent earth scientists. The major theme of the course is the process of science and its application to solve earth science problems. The course stresses graphical analysis, reasoning skills as well as the development and recognition of conceptual relationships. The complexity of the material covered gradually increases during the year with an in-depth study of past, present and future problems and their solutions. Some of the major topics covered during the year include the following: density, astronomy, global warming, earthquakes, volcanism, plate tectonics and meteorology.

XL. **RATIONALE**

The science curriculum is made up of units that encourage student interest and inquiry in the continuing pursuit of earth science. Students learn how to gather, analyze, and evaluate data that will enable them to use higher thinking skills as they continue their study of science. The major theme of the course is the process of science and its application to solve earth science problems. Additionally, an understanding of the scientific process (scientific method, rational thinking skills, etc) is essential for students to sort and evaluate incoming information.

XLI. **STANDARDS (* NJ CCCS Science is no longer supported by the State of NJ DOE and have moved to NGSS Next Generation Science Standards)**

Standards: The following list identifies the cross-referencing of the New Jersey Core Curriculum Standards with the District Goals for Atlantic City Public Schools including Inclusion/LRC per IEP Planning Code Book (revised 2008).

5.13 All students will develop problem-solving, decision-making, and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systematic observations, interpreting and analyzing data, drawing conclusions, and communicating results.

5.14 All students will develop an understanding of how people of various cultures have contributed to the advancement of science and technology, and how major discoveries and events have advanced science and technology.

5.15 All students will integrate mathematics as a tool for problem solving in science, and as a means of expressing and /or modeling scientific theories.

5.16 All students will understand the interrelationships between science and technology and develop a conceptual understanding of the nature and process of technology.

5.17 All students will gain an understanding of the structure, characteristics, and basic needs of organisms.

5.18 All students will gain an understanding of the structure and behavior of matter.

5.19 All students will gain an understanding of natural laws as they apply to motion, forces, and energy transformations.

5.20 All students will gain an understanding of the structure, dynamics, and geophysical systems of the earth.

5.21 All students will gain an understanding of the origin, evolution, and structure of the universe.

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5.22 All students will develop an understanding of the environment as a system of interdependent components affected by human activity and natural phenomena.

Next Generation Science Standards (NGSS)

High School Earth and Space Sciences

Students in high school develop understanding of a wide range of topics in Earth and space science (ESS) that build upon science concepts from middle school through more advanced content, practice, and crosscutting themes. There are five ESS standard topics in middle school: Space Systems, History of Earth, Earth's Systems, Weather and Climate, and Human Sustainability. The content of the performance expectations are based on current community-based geoscience literacy efforts such as the Earth Science

Literacy Principles is presented with a greater emphasis on an Earth Systems Science approach. There are strong connections to mathematical practices of analyzing and interpreting data. The performance expectations strongly reflect the many societally relevant aspects of ESS (resources, hazards, environmental impacts) with an emphasis on using engineering and technology concepts to design solutions to challenges facing human society.

Space Systems: High school students can examine the processes governing the formation, evolution, and workings of the solar system and universe. Some concepts studied are fundamental to science, such as understanding how the matter of our world formed during the Big Bang and within the cores of stars. Others concepts are practical, such as understanding how short-term changes in the behavior of our sun directly affect humans. Engineering and technology play a large role here in obtaining and analyzing the data that support the theories of the formation of the solar system and universe.

History of Earth: Students can construct explanations for the scales of time over which Earth processes operate. An important aspect of Earth and space science involves making inferences about events in Earth's history based on a data record that is increasingly incomplete that farther you go back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record. A key to Earth's history is the coevolution of the biosphere with Earth's other systems, not only in the ways that climate and environmental changes have shaped the course of evolution but also in how emerging life forms have been responsible for changing Earth.

Earth's Systems: Students can develop models and explanations for the ways that feedbacks between different Earth systems control the appearance of Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface (e.g., volcanism and mountain building), and the sun- driven surface systems that tear down the land through weathering and erosion. Students understand the role that water plays in affecting weather. Students understand chemical cycles such as the carbon cycle. Students can examine the ways that human activities cause feedbacks that create changes to other systems.

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Weather and Climate: Students understand the system interactions that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students understand the analysis and interpretation of different kinds of geoscience data allow students to construct explanations for the many factors that drive climate change over a wide range of time scales.

Human Impacts: Students understand the complex and significant interdependencies between humans and the rest of Earth's systems through the impacts of natural hazards, our dependencies on natural resources, and the environmental impacts of human activities.

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HS. Space Systems

HS. Space Systems

Students who demonstrate understanding can:

HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.]

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1)

Using Mathematical and Computational Thinking
Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
- Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2)

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.
- Communicate scientific ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2)

Disciplinary Core Ideas

ESS1.A: The Universe and Its Stars
- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)
- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)
- The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2)
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2),(HS-ESS1-3)

ESS1.B: Earth and the Solar System
- Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)

PS3.D: Energy in Chemical Processes and Everyday Life
- Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary to HS-ESS1-1)

PS4.B Electromagnetic Radiation
- Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2)

Crosscutting Concepts

Scale, Proportion, and Quantity
- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)
- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4)

Energy and Matter
- Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)

Connection to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
- Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2),(HS-ESS1-4)

Connection to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)
- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

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HS. History of Earth

HS. History of Earth

Students who demonstrate understanding can:

HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).]

HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-1)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
- Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (MS-ESS1-6)

Engaging in Argument from Evidence
Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.
- Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-6)
- Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6)

Disciplinary Core Ideas

ESS1.C: The History of Planet Earth
- Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)
- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)

ESS2.A: Earth Materials and Systems
- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. A deep knowledge of how feedbacks work within and among Earth's systems is still lacking, thus limiting scientists' ability to predict some changes and their impacts. (HS-ESS2-1) (Note: This Disciplinary Core Idea is also addressed by HS-ESS2-2.)

ESS2.B: Plate Tectonics and Large-Scale System Interactions
- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5),(HS-ESS2-1)
- Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) (HS-ESS2-1)

PS1.C: Nuclear Processes
- Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary to HS-ESS1-5),(secondary to HS-ESS1-6)

Crosscutting Concepts

Patterns
- Empirical evidence is needed to identify patterns. (HS-ESS1-5)

Stability and Change
- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)

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HS. Earth's Systems

HS. Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]

HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.]

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth systems and life on Earth. [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.]

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Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3),(HS-ESS2-6)

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5)

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Construct an oral and written argument or counter-arguments based on data and evidence. (HS-ESS2-7)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence. (HS-

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System

- Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary to HS-ESS2-4)

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes (HS-ESS2-2)
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)

ESS2.C: The Roles of Water in Earth's Surface Processes

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2),(HS-ESS2-4)
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)

Energy and Matter

- The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6)
- Energy drives the cycling of matter within and between systems. (HS-ESS2-3)

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7)
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

Connections to Engineering, Technology and Applications of Science

Interdependence of Science, Engineering, and Technology

- Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists,

ESS2-3) ▪ Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3) ▪ Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3)	▪ Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6) **ESS2.E: Biogeology** ▪ The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7) **PS4.A: Wave Properties** Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3)	engineers, and others with wide ranges of expertise. (HS-ESS2-3) **Influence of Engineering, Technology, and Science on Society and the Natural World** ▪ New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)

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HS. Weather and Climate

HS. Weather and Climate

Students who demonstrate understanding can:

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4)

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using computational models in order to make valid and reliable scientific claims. (HS-ESS3-5)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods

- Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HS-ESS3-5)
- New technologies advance scientific knowledge. (HS-ESS3-5)

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence. (HS-ESS3-5)
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4), (HS-ESS3-5)

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System

- Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary to HS-ESS2-4)

ESS2.A: Earth Materials and Systems

- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4)

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4),(secondary to HS-ESS2-2)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6),(HS-ESS2-4)

ESS3.D: Global Climate Change

- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-5)

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HS. Human Impacts

HS. Human Impacts
Students who demonstrate understanding can:

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.* [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and Logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational Simulations are created and used based on mathematical models of basic assumptions.

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-ESS3-3)
- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS3-1)
- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4)

Engaging in Argument from Evidence
Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental,

ESS2.D: Weather and Climate

- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (Secondary to HS-ESS3-6)

ESS3.A: Natural Resources

- Resource availability has guided the development of human society. (HS-ESS3-1)
- All forms of energy production and other resource extraction have associated economic, social, environmental, and Geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)

ESS3.B: Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)

ESS3.C: Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)

ETS1.B. Designing Solutions to Engineering Problems

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary to HS-ESS3-2),(secondary to HS-ESS3-4)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6)

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

- Modern civilization depends on major technological systems. (HS-ESS3-1),(HS-ESS3-3)
- Engineers continuously modify these systems to increase benefits while decreasing costs and risks. (HS-ESS3-2),(HS-ESS3-4)
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3)
- Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2)

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*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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ethical considerations). (HS-ESS3-2) --- **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** ▪ Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HS-ESS3-5) ▪ New technologies advance scientific knowledge. (HS-ESS3-5) ▪ Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open- mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings. **Scientific Knowledge is Based on Empirical Evidence** ▪ Science knowledge is based on empirical evidence. (HS-ESS3-5) ▪ Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS3-5)		**Connections to Nature of Science** **Science is a Human Endeavor** ▪ Scientific knowledge is a result of human endeavors, imagination, and creativity. (HS-ESS3-3) **Science Addresses Questions About the Natural and Material World** ▪ Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2) ▪ Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2) ▪ Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)

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XLII. STUDENT OUTCOMES

A. **KNOWLEDGE** (Concepts) Dual Standards: **NJCCCS & NGSS**

The students will (verbally or in writing):

1. Apply scientific research material to determine the solution to a given problem in earth science: Identifying the problem, gathering research information, analyzing and interpreting research information, drawing conclusions, making inferences and predictions.
   [NJ CCCS 5.1, 5.2, 5.7, 5.8] [HS-ESS1-6]
2. Compare the various overviews of scientific theories of the origin of the universe and our solar system.
   [NJ CCCS 5.9] [HS-ESS1-4]
3. Describe the location of the earth in the solar system and the universe.
   [NJ CCCS 5.9] [HS-ESS1-6]
4. Compare the earth, its general composition and dynamic processes with other bodies in our solar system.
   [NJ CCCS 5.9] [HS-ESS-4]
5. Explain the relationship of gravity, tides and seasons to the motion and location of the earth in the solar system.
   [NJ CCCS 5.9] [HS-ESS1.B]
6. Identify and explain the integration of space technology into everyday life in modern society, including: weather satellites, Landsat imagery, communication satellites, materials developed for the space program and used today.
   [NJ CCCS 5.9;5.10] [HS_ESS1A]
7. Demonstrate the ability to make predictions regarding weather using observations from satellite imagery and weather maps.
   [NJ CCCS 5.8,5.9,5.10] [HS-ESS3-5] [HS-ESS2-2]
8. Understand the relationship between the geographic location of an area and climate with regard to the following; land and breezes, latitude and longitude, location of mountain ranges and ocean currents.
   [NJ CCCS 5.8,5.10] [HS-ESS3-6] [HS-ESS2-6
9. Demonstrate and understanding of the dynamic nature of the coastal environment and human activities. Examples are to include; beach evolution and erosion, shoreline and wetlands development, rising sea level, saltwater encroachment, waste disposal, aquaculture and storm damage.
   [NJ CCCS 5.8,5.9,5.10] [HS-ESS3-4, HS-ESS3-5, HS-ESS3-6]
10. Reconstruct geologic history, emphasizing the immensity of geologic time, by using; fossils radioactive dating, structural sequences of rocks and Doctrine of Uniformitarianism.
    [NJ CCCS 5.1,5.2,5.8,5.10] [HS-ESS1-6, HS-ESS2-E]
11. Demonstrate understanding of various global cycles (e.g. hydrologic, Energy CO_2, O_2, N_2) and their importance in geologic processes and explain their interaction in terms of weather and oceanic circulations.
    [NJ CCCS 5.11,5.6,5.8,5.9,5.10] [HS-ESS2-5, HS-ESS2-6,

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HS-ESS2-67]

12. Explain in their own words, the effect of human activities on natural earth processes. Examples to include: deforestation, greenhouse effect, ozone, acid rain, non-point source pollution and litter.
    [NJ CCCS 5.1,5.2,5.8,5.10] [HS-ESS3-6]

B. **ATTITUDES**
   The student will:

1. Appreciate the complexity of modern space technology and its ability to continuously gather new information through space probes, telescopes, and computer analysis.
   [NJ CCCS 5.4] [HS-ESS1-2, HS-ESS1-3]
2. Appreciate the earth's interaction with the sun, moon, and other solar system components.
   [NJ CCCS 5.9] {HS-ESS1-6]
3. Appreciate the characteristics of earth that enable it to support life.
   [NJ CCCS 5.9] [HS-ESS1-6]
4. Appreciate the enormous amount of time required for geologic changes to occur compared to man's time on earth.
   [NJ CCCS 5.8] [HS-ESS1-6, HS-ESS1-C]
5. Appreciate the time and effort that scientists put into studying the earth and its processes in order to better understand how the earth changes.
   [NJ CCCS 5.8] [HS-ESS2-2, HS-ESS2-3, HS-ESS2-7]
6. Develop a sensitivity toward the impact of man on nature and the impact of nature on itself. [5.10] [HS-ESS3-1, HS-ESS3-6]
7. Appreciate the efforts of scientists to use current technology to make predictions and improve the safety of the earth's inhabitants.
   [NJ CCCS 5.8] [HS-ESS3-6, HS-ETS-1B]

C. **SKILLS AND BEHAVIOR**
   The student will:

1. Interpret a diagram that shows how the positions of the earth, sun & moon affect the tides, phases of the moon, and / or eclipses.
   [NJ CCCS 5.9] [HS-ESS1-4]
2. Explain how the motions of the earth, sun and moon define units of time including days, months, and years.
   [NJ CCCS 5.9] [HS-ESS1-, HS-ESS1-B, HS-ESS1-C]
3. Synthesize how the tilt, rotation, and orbital pattern of the earth relative to the sun produces seasons and weather patterns.
   [NJ CCCS 5.9] [HS-ESS1-, HS-ESS1-B, HS-ESS1-C]
4. Describe the physical characteristics of the planets and other objects in the solar system, and compare the earth to other planets.
   [NJ CCCS 5.9] [HS-ESS1-, HS-ESS1-B, HS-ESS1-C]
5. Compute & express quantities using appropriate number formats including scientific

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notation.
[NJ CCCS 5.3] [HS-ESS3-4]

6. Develop models, Synthesize and demonstrate understanding of the scale of the solar system that shows distance and size relationships among the sun and planets.
[NJ CCCS 5.9] [HS-ESS1-, HS-ESS1-B, HS-ESS1-C]
7. Observe and record short-term and long term-changes in the positions of the constellations in the night sky.
[NJ CCCS 5.9] [HS-ESS1-4]
8. Observe that the planets appear to change their positions against the background of stars.
[NJ CCCS 5.9] [HS-ESS1-4, HS-ESS1-B]
9. Discuss the composition, circulation, and distribution of the world's oceans.
[NJ CCCS 5.8] [HS-ESS2-C, HS-ESS2-5]
10. Describe and illustrate the water cycle.
[NJ CCCS 5.8] [HS-ESS2-2, HS-ESS2-5]
11. Summarize the process involved in the rock cycle and describe the characteristics of the rocks involved.
[NJ CCCS 5.8] [HS-ESS-1-5, HS-ESS1-6, HS-ESS2-B]
12. Utilize manipulatives such as technology, devices, tools, map projections and topographical maps to interpret features of the earth's surface.
[NJ CCCS 5.8] [HS-ESS2-1, HS-ESS2-3, HS-ESS2-4]
13. Describe and synthesize conditions in the atmosphere and other processes that lead to weather systems and how these weather systems are represented on weather maps.
[NJ CCCS 5.8] [HS-ESS2-6, HS-ESS3-6]
14. Explain, describe and discuss how the earth's landforms and materials are created through constructive and destructive forces - earthquakes and volcanoes.
[NJ CCCS 5.8] [HS-ESS1-5, HS-ESS2-1]
15. Explain how technology designed to investigate features of the earth's surface impacts how scientists study the earth.
[NJ CCCS 5.8] [HS-ESS3-6, HS-ETS-B]
16. Show that vibrations in materials can generate waves that can transfer energy from one place to another.
[NJ CCCS 5.7] {HS-ESS2-A, HS-ESS2-3, HS-ESS2-4]
17. Classify a sample into one of the three major classifications of rock.
[NJ CCCS 5.9] [HS-ESS2-1]
18. Argue and discuss the connections between educational activities and the world or work.
19. [NJ CCCS 9:1, 9:2] [HS-ESS3-6, HS-ETS-B]

VIII. STRATEGIES

The following strategies/activities will be used:

1. Inquiry - including the development of hypotheses, experiments and the resulting conclusions

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2. Cooperative learning
3. Hands-on approach with the use and creation (for example) of models to represent movement of heat through a system, creation of an earthquake proof structure, and the use of model magma and soil to represent a volcano
4. Use of notebook or learning log to record hypotheses, observations, reflections, conclusions and other information gathered
5. Create tables, charts, and/or graphs to gather and present information
6. Access to internet, databases and other print and non-print resources to research further information about the topics covered
7. Various reading and writing in the content areas strategies as presented in district workshops
8. Modify lesson plans per inclusion teacher when necessary for student(s), per IEP code book.

   [Atlantic City Public School District Special Education Department]
9. Make the appropriate accommodations for special needs and ELL students:

   Additional time and other IEP stated accommodations

   Audio text resources, varied assessments

IX. **EVALUATION**

Assessment will include:

Unit Exams
Chapter and Vocabulary Quizzes
Lab reports
Notebook
Performance Assessment
Homework
Class Participation

Students will also be expected to design and execute projects and/or original research.

Benchmark Exams

X. REQUIRED RESOURCES

1. **Student resources:**

   Textbook: Earth Science, *Geology, the Environment and the Universe* Textbook, Authors; Hess, Kunze Leslie, et al, National Geographic Society., Glencoe Merrill 2005

2. **Other Resources**

   Holt Science Spectrum, Holt Rinehart & Winston, 2001
   Earth Science, Transparencies, Feather, et.al., Glencoe Merrill 1999
   Globe Earth Science Workbooks, Bunch, et.al., Globe-Fearon 1999

   Prentice Hall Earth Science Resources:
   http://www.phschool.com/webcodes10/index.cfm?area=view&wcprefix=cuk&wcsuffix=9999

   Media Center and classroom print and non-print resources

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Variety of materials for hands on labs and activities
Videos/films/NBC Learn
Computer resources including the internet and databases

3. **Technology**
   Computers/laptops
   Internet Resources
   Lab Materials/Kits

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XI. SCOPE AND SEQUENCE

September – Unit #1

Introduction to Earth Science
Scientific Method
Periodic table
Measurements and metric conversions
Geography-finding positions on earth using maps, charts and globes.
Maps and plotting position

Assessments: Classwork, homework, quizzes/tests, Pre-Test, class projects-Labs

October – Unit #4

Meteorology-description, measurements and instruments.
Climate vs. weather
Weather forecasting
Clouds, fronts and precipitation
Ozone layer.
Layers of the atmosphere
Air currents, air masses and Coriolis Effect
La Nina-El Nino, Sea Surface Temperatures
Global warming
Severe weather-hurricanes, tornadoes storms.

Assessments: Classwork, homework, , quizzes/tests class projects, Labs

November – Unit #4

Ocean composition and origins
Ocean currents-gulf stream
Weather and ocean currents
Tides and oceans waves
River systems
Coral reefs and shoreline structures.
Seafloor structures.

Assessments: Classwork, homework, quizzes/tests, MP 1 Benchmark class projects, Labs

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December Unit #4

Plankton and photosynthesis
Marine animals
Life processes in the ocean.
Ocean pollution
Consequences of pollution
Preventing ocean pollution

Assessments: Classwork, homework, quizzes/tests, class projects, LABS

January – Unit #3

Weathering
Erosion
Deposition and landforms
Soil
Surface processes
Mass movements
Glaciers
Desertification
Rivers systems-deltas, floodplains, watersheds

Assessments: Classwork, homework, quizzes/tests, Mid-Term Benchmark class projects

February – Unit #2

Minerals
Rock cycle
Igneous rocks
Metamorphic rocks
Sedimentary rocks
Fossils
Plate tectonics
Earth Layers

Assessments: Classwork, homework, quizzes/tests class projects

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March Unit - #5

Dynamic earth processes
Earth interior-lithosphere
Plate movements
Properties of the crust
Mountain formation
Earthquakes
Volcanoes
Ring of Fire

Assessments: Classwork, homework, quizzes/tests class projects

April - Unit #6

Volcano eruptions
Geothermal energy
Geologic time
Eras, epochs and period in time
Fossils and geology
Dinosaurs
Extinction
Human interaction with species

Assessments: Classwork, homework, quizzes/tests class projects

May/June - Units #7 & #8

Earth-Moon system
Inner Planets
Outer Planets
The Sun
Solar System
Space travel
Mars exploration
Formation of the Universe, (Big Bang Theory)
Galaxies and Stars and Stellar formation and distribution
Instruments used to view and study the universe.

Assessments: Classwork, homework, quizzes/tests class projects, FINAL EXAM/Benchmark Test.

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Rubric for Science Assessment Items, Tasks, and Prompts

Level	Dimension 1: Alignment to Focal PE(s)	Dimension 2: Appropriateness of Scenario	Dimension 3: Integration of Science and Engineering Practices	Dimension 4: Integration of Crosscutting Concepts
4	• Every prompt elicits elements of a Disciplinary Core Idea (DCI) in combination with a Science and Engineering Practice (SEP) and/or a Crosscutting Concept (CCC) which have been unpacked from the target Performance Expectation(s) (PE). • The answers required are appropriate for the grade or grade band of the students. • The rubric(s) assigns the level of quality of student responses in all three dimensions.	• The scenario can be explained by the application of elements of the SEPs and CCCs to explain how or why (science) phenomenon occur or justify a solution (model) to a design challenge. • The scenario is accessible to all groups of learners.	• Multiple prompts require students to use specific elements of unpacked SEPs and DCIs. • The SEP from the focal PE are paired with one or more complimentary SEPs. • Teachers use Task Formats that are appropriate to the grade level or grade band of the PE as outlined in the Matrix of Science and Engineering Practices. • The SEP is clearly visible in the tasks.	• Multiple prompts require students to use specific elements of unpacked CCCs and DCIs. • The CCC from the focal PE are paired with one or more complimentary CCCs. • Teachers use Task Formats that are appropriate to the grade level or grade band of the PE as outlined in the Matrix of the Crosscutting Concepts. • The CCC is clearly visible in the tasks.
3	• Most prompts elicits elements of a Disciplinary Core Idea (DCI) in combination with a Science and Engineering Practice (SEP) and/or a Crosscutting Concept (CCC) which have been unpacked from the target Performance Expectation(s) (PE). • Some answers required use of DCI, SEP, and or CCC that are below grade level. • The rubric(s) assigns numerical values for student responses and do not differentiate among the dimensions.	• The scenario is more relevant and engaging to the teacher than the students. • The scenario is aligned to the topic but it needs additional clarifications so that students can connect it with their understandings. • The scenario is likely to be accessible by most groups of learners.	• A single prompt requires students to use specific elements of unpacked SEPs and DCIs. • The SEP from the focal PE are the only SEPs used by students. • Teachers use Task Formats to write the assessments but some tasks are above or below grade level. • The SEP is inferred in the tasks.	• A single prompts require students to use specific elements of unpacked CCCs and DCIs. • The CCC from the focal PE is the only CCCs used by students. • Teachers use Task Formats to write the assessments but some tasks are above or below grade level. • The CCC is inferred in the tasks.

Level	Dimension 1: Alignment to Focal PE(s)	Dimension 2: Appropriateness of Scenario	Dimension 3: Integration of Science and Engineering Practices	Dimension 4: Integration of Crosscutting Concepts
2	• The scenario is on topic but does not require the integrated use of a Disciplinary Core Idea (DCI) in combination with a Science and Engineering Practice (SEP) and/or a Crosscutting Concept (CCC) to explain or solve. • Some prompts elicit some ancillary restatement of a sub-component of a DCI, CCC, or SEP. • Most answers required are below or above the grade level or grade band of the PE. • The rubric(s) mostly gives emphasis to a single dimension.	• It is not obvious to recognize how the scenario is related to the topic. • The scenario not likely to be accessible to most learners.	• The prompts do not requires students to use a science and engineering practice.	• The prompts do not require students to use a crosscutting concepts.
1	• The item or task is not asking students to use a SEP or CCC. • The item or task response is either correct or incorrect and can be scored with an answer key.	• There is no scenario in the assessment. The scenario is not likely to be accessible to learners.	• The items are based on cognitive verbs rather than language from the SEPs.	• The items are based on cognitive verbs rather than language from the CCCs.

Credit: This rubric is based on Penuel, W. R., Van Horne, K., & Bell, P. (2016). Practice Brief: Steps to Designing a Three Dimensional Assessment (Publication No. 29). Seattle, WA: University of Washington Institute for Science Math Education.

Rubric for Formal Lab Reports in Science

CATEGORY	Exceptional (4)	Satisfactory (3)	Unsatisfactory (2)	Poor (1)
Introduction	Your introduction clearly states the purpose of the lab and you explicitly state the variables that are to be studied.	Your introduction states the purpose of the lab and the variables to be studied.	Your introduction states the purpose of the lab, but not the variables that will be studied.	There is no introduction.
Experimental Hypothesis	Hypothesized relationship between the variables and the predicted results is clear and reasonable based on what has been studied.	Hypothesized relationship between the variables and the predicted results is reasonable based on general knowledge and observations.	Hypothesized relationship between the variables and the predicted results has been stated, but appears to be based on flawed logic.	No hypothesis has been stated.
Materials	All materials and setup used in the experiment are clearly and accurately described. Drawings included as appropriate.	Almost all materials and the setup used in the experiment are clearly and accurately described.	Most of the materials and the setup used in the experiment are accurately described.	Many materials are described inaccurately OR are not described at all.
Procedures	Procedures are listed in clear steps. Each step is numbered and is a complete sentence.	Procedures are listed in a logical order, but steps are not numbered and/or are not in complete sentences.	Procedures are listed but are not in a logical order or are difficult to follow.	Procedures do not accurately list the steps of the experiment.
Data	Professional looking and accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled. Drawings are included as necessary and are well labeled.	Accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled. Drawings are included when necessary.	Accurate representation of the data in written form, but no graphs or tables are presented.	Data are not shown OR are inaccurate.
Analysis	The relationship between the variables is discussed and trends/patterns logically analyzed. Predictions are made about what might happen if part of the lab were changed or how the experimental design could be changed.	The relationship between the variables is discussed and trends/patterns logically analyzed.	The relationship between the variables is discussed but no patterns, trends or predictions are made based on the data.	The relationship between the variables is not discussed.

Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.