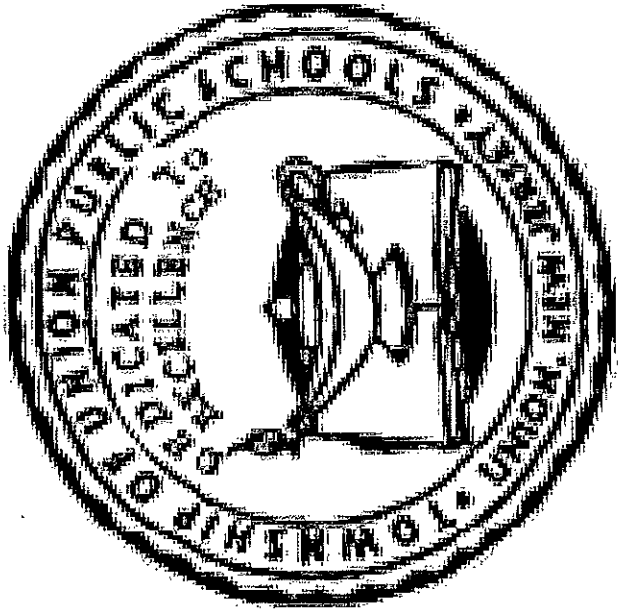


TOWNSHIP OF UNION PUBLIC SCHOOLS



College Preparatory Chemistry

Curriculum Guide 2016

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Academic Area

Chemistry

References

The following curriculum guide was adapted from the Next Generation Science Standards and the State of New Jersey Department of Education High School Chemistry Model Curriculum.

"Model Curriculum: HS Chemistry." *Model Curriculum: HS Chemistry*. State of New Jersey. 2014. Web. 26 Apr. 2016.

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press. Web. 26 Apr. 2016.



Curriculum Unit Overview

Unit 1 - Structure and Properties of Matter

Unit 2 – Energy of Chemical Systems

Unit 3 - Bonding and Chemical Reactions

Unit 4 – Matter and Energy in Living Systems

Unit 5 – Nuclear Chemistry

Curriculum Pacing Guide – College Preparatory Chemistry

<u>Unit Name</u>	<u>Estimated Number of Days</u>
Unit 1- Structure and Properties of Matter	30
Unit 2- Energy of Chemical Systems	20
Unit 3- Bonding and Chemical Reactions	30
Unit 4- Matter and Energy in Living Systems	20
Unit 5- Nuclear Chemistry	30

Course Proficiencies

For all units, students will understand and follow all laboratory and safety rules, understand scientific explanations, general scientific evidence through active investigations, reflection on scientific knowledge, and participate productively in science.

Unit 1: Structure and Properties of Matter

In this unit of study, students use investigations, simulations, and models to make 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.

HS-PS1-1, HS-PS1-2, HS-PS1-3, HS-PS2-6, HS-ETS1-3, and HS-ETS1-4.

Unit 2: Energy of Chemical Systems

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.
HS-PS3-4.

Unit 3: Bonding and Chemical Reactions

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*.

HS-PS1-7, HS-PS1-4, HS-PS1-5, HS-PS1-6, and HS-ETS1-2.

Unit 4: Matter and Energy in Living Systems

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.

HS-LS1-7 and HS-LS1-6.

Unit 5: Nuclear Chemistry

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.

HS-PS1-8, HS-ESS1-3, HS-ESS1-1, HS-ESS1-2, and HS-ESS1-6

Course Description

This course is specifically designed for the science oriented students and those students who are contemplating the attending of a four-year college upon graduating from high school. Chemistry is a scientific discipline which is important to students because it teaches them to think abstractly, to solve mathematical problems, and to learn applicable scientific concepts necessary for success in our modern world.

Recommended Textbooks

Chemistry: Prentice Hall

Unit 1 – Summary: Structure and Properties of Matter

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

In this unit of study, students use investigations, simulations, and models to make 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.

Student Learning Objectives

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)

Part A: How can a periodic table tell me about the subatomic structure of a substance?	Concepts	Formative Assessment
	<ul style="list-style-type: none"> 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. 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> 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
	<ul style="list-style-type: none"> 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 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> 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.

<p>is studied, and these patterns can provide evidence for causality in explanations of phenomena.</p>	<ul style="list-style-type: none"> • 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.
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<p>Part C: How can I use the properties of something (in bulk quantities) to predict what is happening with the subatomic particles?</p>	
<p style="text-align: center;">Formative Assessment</p>	
<p>Concepts</p> <ul style="list-style-type: none"> • 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. 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> • 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.

<p>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.]</p>	
<p style="text-align: center;">Formative Assessment</p>	
<p>Concepts</p> <ul style="list-style-type: none"> • 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 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> • 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.

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 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.

Connecting with English Language Arts/Literacy and Mathematics

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.

Suggested Learning Activities

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.

Reactivity of Alkaline Earth Metals Lab – Students will investigate the reactivity of the alkaline earth metals and determine the pattern of reactivity found in the periodic table.

Ionic and Covalent Lab – Students will test physical properties of substances and classify them according to nonpolar covalent, polar covalent or ionic.

Law of Conservation of Mass Demonstration - Students will develop a procedure and implement it to investigate the law of conservation of mass.

Chemical Reactions Lab - Students are given a list of reactants. They are to perform each reaction, determine the evidence of a reaction, and classify the reaction according to type.

Intermolecular Forces Activity - Students will determine the type of intermolecular forces holding various substances together, and rank them according to their strength.

Liquids and Solids Demo/Activity – Students conduct an investigation to explain at the atomic level transformations of matter by collecting data to create cooling and heating curves.

Methods of Assessment

Do Now, Exit Tickets, Question and Answer Techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental, Cumulative Assessments, Lab Performance and Analysis, Classroom and Homework Reinforcement Techniques, Discussion

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-PS1-2)*

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)*

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
<p>Developing and Using Models</p> <ul style="list-style-type: none"> Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) <p>Planning and Carrying Out Investigations</p> <ul style="list-style-type: none"> 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) <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> 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) <p>Obtaining, Evaluating, and Communicating Information</p> <ul style="list-style-type: none"> Communicate scientific and technical information (e.g. about the process of 	<p>PS1.A: Structure and Properties of Matter</p> <ul style="list-style-type: none"> 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. (secondary to HS-PS2-6) <p>PS1.B: Chemical Reactions</p> <ul style="list-style-type: none"> 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) <p>PS2.B: Types of Interactions</p> <ul style="list-style-type: none"> 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) <p>ESS2.D: Weather and Climate</p> <ul style="list-style-type: none"> Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) 	<p>Patterns</p> <ul style="list-style-type: none"> 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) <p>Structure and Function</p> <ul style="list-style-type: none"> 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) <p>Systems and System Models</p> <ul style="list-style-type: none"> 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) <p>-----</p> <p>Connections to Engineering, Technology, and Applications of Science Influence on Society and the Natural World</p> <p>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)</p>

<p>development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)</p> <p>Using Mathematics and Computational Thinking</p> <ul style="list-style-type: none"> 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) 	<p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> 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) 	
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<p>Embedded English Language Arts/Literacy and Mathematics Standards</p>		
<p><i>English Language Arts/Literacy</i></p> <p>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)</p> <p>WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)</p> <p>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)</p> <p>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)</p> <p>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)</p>		

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)
<i>Mathematics</i>	
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 Summary ~ Energy and Chemical Systems

How is energy transferred within a system?

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.

Student Learning Objectives

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?

Concepts

- 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.

Formative Assessment

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

Connecting with English Language Arts/Literacy and Mathematics

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.

Suggesting Learning Activities

Phet heat transfer simulation

Heat Transfer Activity – student investigate heat transfer using different materials such as metals using the specific heat for these substances.

Methods of Assessment

Do Now, Exit Tickets, Question and Answer Techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental, Cumulative Assessments, Lab Performance and Analysis, Classwork and Homework Reinforcement Techniques, Discussion

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 <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> 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)

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)
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 – Summary: Bonding and Chemical Reactions

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

In this unit of study, students 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 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.

Student Learning Objectives

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 Chatelier'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)

Part A: Where do the atoms go during a chemical reaction?	
Concepts	Formative Assessment
<ul style="list-style-type: none"> 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. 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> 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
<ul style="list-style-type: none"> 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 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> 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

<p>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.</p>	<p>changes in total bond energy.</p>
<p>Part C: Is it possible to change the rate of a reaction or cause two elements to react that do not normally want to?</p>	
<p>Concepts</p> <ul style="list-style-type: none"> • 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. 	<p>Formative Assessment</p> <p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> • Use the number and energy of collisions between molecules (particles) to explain the effects of changing the temperature or concentration of the reacting particles 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.
<p>Part D: What can we do to make the products of a reaction stable?</p>	
<p>Concepts</p> <ul style="list-style-type: none"> • 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. 	<p>Formative Assessment</p> <p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> • 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. • 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.

Connecting with English Language Arts/Literacy

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.

Suggested Learning Activities

Endothermic/Exothermic Reaction – Students will be able to determine whether energy was absorbed or released during several demonstrations.

Water in a Hydrate – Students calculate the percent water in an unknown hydrate, calculate the empirical formula of the hydrate, and then use this information to determine the identity of the hydrate.

Percent Composition Activity

Counting by Weighing (Counting Large Numbers)– Students calculate how many items are in a sample without actually counting them.

Limiting Reactant Lab/Percent Yield – Students determine the limiting reactant in a lab experiment and calculate their percent yield.

Heating/Cooling Curve/Phase Diagrams (Heat of Fusion of Ice) – Students perform a simple chemical reaction and explain what is happening in terms of energy changes.

Le Chatelier's Activity – Students investigate the effect of changing the temperature or concentration on the outcome of the reaction.

Methods of Assessment

Do Now, Exit Tickets, Question and Answer Techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental, Cumulative Assessments, Lab Performance and Analysis, Classroom and Homework Reinforcement Techniques, Discussion

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 Chatelier'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
<p>Developing and Using Models</p> <ul style="list-style-type: none"> 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) <p>Planning and Carrying Out Investigations</p> <ul style="list-style-type: none"> 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) <p>Using Mathematics and Computational Thinking</p> <ul style="list-style-type: none"> Use mathematical representations of phenomena to support claims. (HS-PS1-7) <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> 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) 	<p>PS1.A: Structure and Properties of Matter</p> <ul style="list-style-type: none"> 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) 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) <p>PS1.B: Chemical Reactions</p> <ul style="list-style-type: none"> 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) 	<p>Patterns</p> <ul style="list-style-type: none"> 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) <p>Energy and Matter</p> <ul style="list-style-type: none"> 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 energy and matter flows into, out of, and within that system. (HS-PS1-4) <p>Stability and Change</p> <ul style="list-style-type: none"> Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)
		<p>-----</p> <p>Connections to Nature of Science</p> <p>Scientific Knowledge Assumes an Order and Consistency in Natural Systems</p> <ul style="list-style-type: none"> Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

<ul style="list-style-type: none"> 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) <p>Asking Questions and Defining Problems</p> <ul style="list-style-type: none"> Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) <p>Using Mathematics and Computational Thinking</p> <ul style="list-style-type: none"> 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) <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> 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) 	<ul style="list-style-type: none"> 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) <p>PS1.C: Nuclear Processes</p> <ul style="list-style-type: none"> 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) <p>PS2.B: Types of Interactions</p> <ul style="list-style-type: none"> 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) <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> 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) <p>ETS1.A: Defining and Delimiting Engineering Problems</p> <ul style="list-style-type: none"> 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 	
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	<p>pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)</p> <p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> • 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) <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> • 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) 	
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Embedded English Language Arts/Literacy and Mathematics	
<p><i>English Language Arts/Literacy</i></p> <p>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)</p>	

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)
<i>Mathematics -</i>	
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 - Summary Matter and Energy in Living Systems

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.

Student Learning Objectives

- 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)*

Part A: How does photosynthesis transform light energy into stored chemical energy?

Concepts	Formative Assessment
<ul style="list-style-type: none"> • 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. 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> • 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
<ul style="list-style-type: none"> 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. 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> 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
<ul style="list-style-type: none"> 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. 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> 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.

Connecting with English Language Arts/Literacy

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.

Suggested Learning Activities

Model Building – Students use model kits to build molecules involved in respiration and photosynthesis to illustrate how bonds are broken and atoms are rearranged in the process. Students also build molecules showing that carbon and hydrogen provide the basis of hydrocarbon, illustrating their importance in biological processes.

Polymerization lab-/Food chemistry lab –Students research and investigate how simple sugars (made from carbon, hydrogen and oxygen) are combined and recombined in different structures with specific functions.

Proof of CO₂ in Exhalation Activity– Students test the products of cellular respiration found in their breathe to verify that CO₂ is a product of respiration.

Petri dish Toxicity testing– Students categorize each growth medium according to its acidity, basicity, polarity, etc and test to see which medium is most conducive to growth of radish seeds.

Methods of Assessment

Do Now, Exit Tickets, Question and Answer Techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental, Cumulative Assessments, Lab Performance and Analysis, Classroom and Homework Reinforcement Techniques, Discussion

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
<p>Developing and Using Models</p> <ul style="list-style-type: none"> Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-5),(HS-LS1-7) <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> 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) 	<p>LS1.A: Structure and Function</p> <ul style="list-style-type: none"> 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 	<p>Energy and Matter</p> <ul style="list-style-type: none"> 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)

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)

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

	<p>form different products. (HS-LS1-6),(HS-LS1-7)</p> <ul style="list-style-type: none"> 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)
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Embedded English Language Arts/Literacy and Mathematics Standards	
<i>English Language Arts/Literacy</i>	
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)
<i>Mathematics</i>	
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- Summary Nuclear Chemistry

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.

Student Learning Objectives

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)

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?

Concepts

Formative Assessment

- Nuclear processes, including fusion, fission, and radioactive decay of
Students who understand the concepts are able to:

<p>unstable nuclei, involve release or absorption of energy.</p> <ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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.
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<p>Part B: How do stars produce elements?</p>	
<p>Concepts</p> <ul style="list-style-type: none"> 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. 	<p>Formative Assessment</p> <p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> 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.

<p>Part C: Is the life span of a star predictable?</p>	
<p>Concepts</p> <ul style="list-style-type: none"> 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. 	<p>Formative Assessment</p> <p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> 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
<ul style="list-style-type: none"> 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. 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 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. 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> 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.

Part E: How can chemistry help us to figure out ancient events?	
Concepts	Formative Assessment
<ul style="list-style-type: none"> 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. 	<p><i>Students who understand the concepts are able to:</i></p> <ul style="list-style-type: none"> 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.

Suggested Learning Activities

Modeling a Radioactive Decay series Activity- Students model radioactive decay of various elements.

PhET Nuclear Fission inquiry lab and graphs- Students are able to illustrate the changes in the composition of the nucleus of the energy released during the process of alpha, beta and gamma radioactive decay.

Spectroscope/Flame Test Lab- Students use spectroscopes to analyze emission spectra given off by various gases. In addition, the flame test allows students to explore what happens in terms of electrons when metals are vaporized in a flame. Students calculate the amount of energy released using $E = hv$.

Radiometric Dating simulation- Students use examples of spontaneous radioactive decay as a tool to determine the ages of rocks or other materials.

Connecting with 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)

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)

Methods of Assessment

Do Now's, Exit Tickets, Question and Answer Techniques, Polling, Debate, Quizzes, Projects, Writing Prompts, Exams, Departmental, Cumulative Assessments, Lab Performance and Analysis, Classroom and Homework Reinforcement Techniques, Discussion

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*:

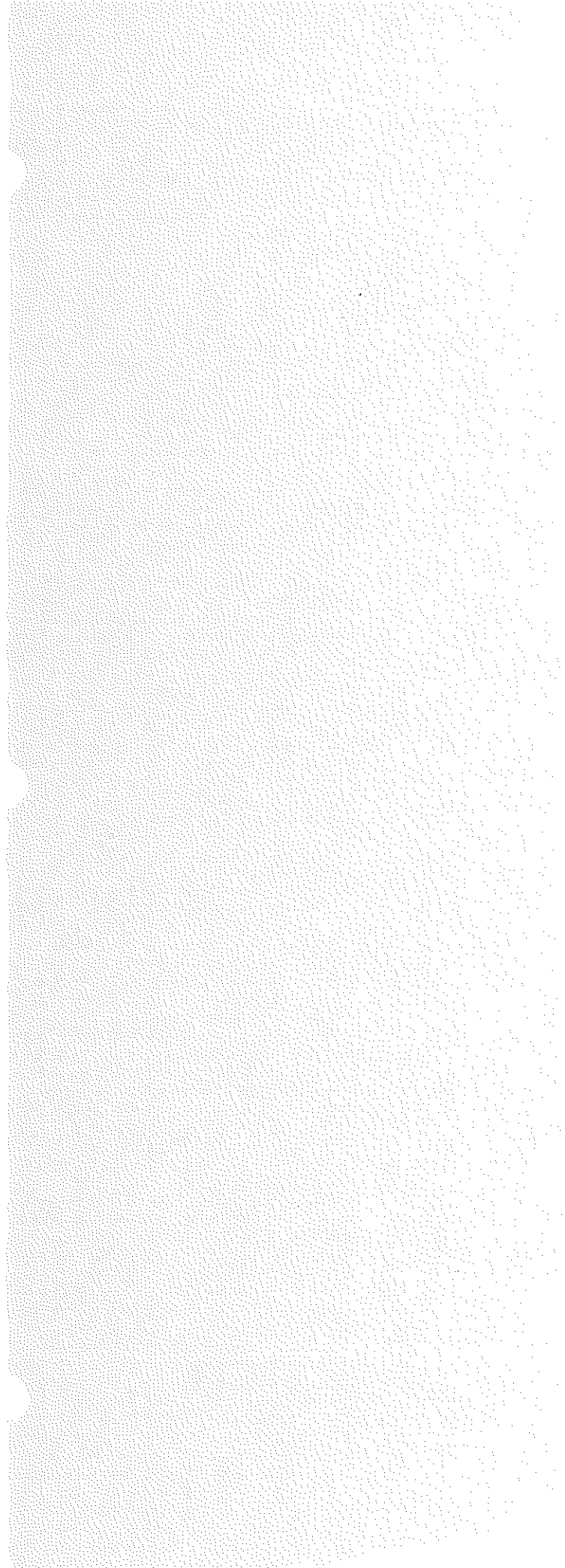
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>Developing and Using Models</p> <p>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.</p> <ul style="list-style-type: none"> Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8),(HS-ESS1-1) <p>Constructing Explanations and Designing Solutions</p> <p>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.</p> <ul style="list-style-type: none"> 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) <p>Using Mathematical and Computational Thinking</p> <p>Mathematical and computational thinking in 9–12</p>	<p>PS1.C: Nuclear Processes</p> <ul style="list-style-type: none"> 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) <p>ESS1.A: The Universe and Its Stars</p> <ul style="list-style-type: none"> 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 	<p>Energy and Matter</p> <ul style="list-style-type: none"> 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) <p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> 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) In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. <p>Stability and Change</p> <ul style="list-style-type: none"> Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) <p>-----</p> <p>Connections to Engineering, Technology, and Applications of Science</p> <p>Interdependence of Science, Engineering, and</p>

<p>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.</p> <ul style="list-style-type: none"> Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4) <p>Obtaining, Evaluating, and Communicating Information</p> <ul style="list-style-type: none"> 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) 	<p>supernova stage and explode. (HS-ESS1-2),(HS-ESS1-3)</p> <p>PS3.D: Energy in Chemical Processes and Everyday Life</p> <ul style="list-style-type: none"> Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary) (HS-ESS1-1) <p>PS4.B: Electromagnetic Radiation</p> <ul style="list-style-type: none"> 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) <p>ESS1.B: Earth and the Solar System</p> <ul style="list-style-type: none"> 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) <p>ESS1.C: The History of Planet Earth</p> <ul style="list-style-type: none"> 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. 	<p>Technology</p> <ul style="list-style-type: none"> 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) <p>-----</p> <p>Connections to Nature of Science</p> <p>Scientific Knowledge Assumes an Order and Consistency in Natural Systems</p> <ul style="list-style-type: none"> 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) <p>Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</p> <ul style="list-style-type: none"> 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)
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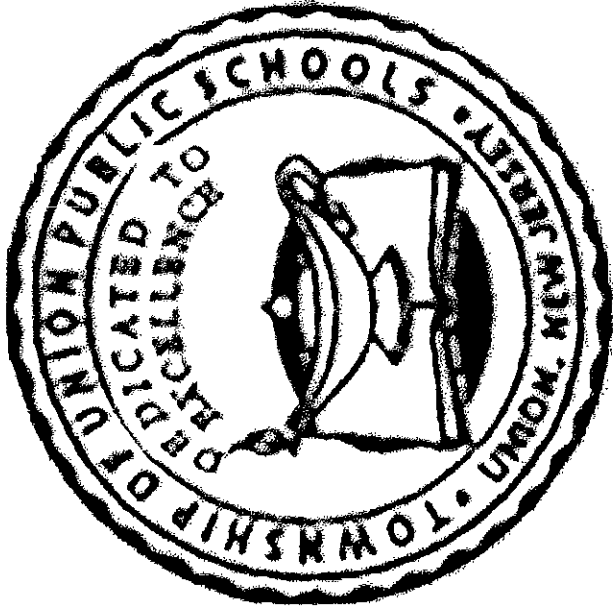
Embedded English Language Arts/Literacy and Mathematics

English Language Arts/Literacy -

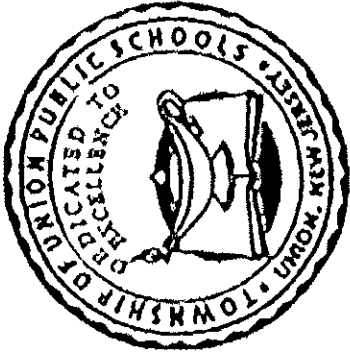
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS1-1)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, 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)
<i>Mathematics -</i>	
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)



TOWNSHIP OF UNION PUBLIC SCHOOLS



**Environmental Science
Curriculum Guide
2016**



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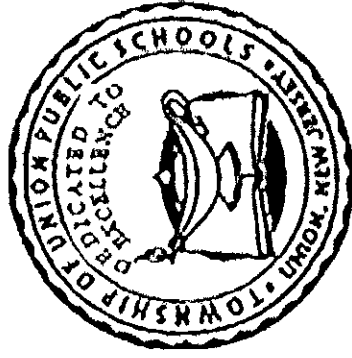
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TOWNSHIP OF UNION PUBLIC SCHOOLS

Administration

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DEPARTMENT SUPERVISORS

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Mathematics/Science 2-5	Ms. Theresa Matthews
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Science 6-12	Ms. Maureen Guilfoyle
Math 6-12.....	Dr. Jeremy Cohen
Social Studies/Business	Ms. Libby Galante
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**Curriculum Committee
Academic Area**

Maureen Guilfoyle, Supervisor of Science

**Stephen Piotrowski
Adam Raffaele**

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Mission Statement

The mission of the Township of Union Public Schools is to build on the foundations of honesty, excellence, integrity, strong family, and community partnerships. We promote a supportive learning environment where every student is challenged, inspired, empowered, and respected as diverse learners. Through cultivation of students' intellectual curiosity, skills and knowledge, our students can achieve academically and socially, and contribute as responsible and productive citizens of our global community.

Philosophy Statement

The Township of Union Public School District, as a societal agency, reflects democratic ideals and concepts through its educational practices. It is the belief of the Board of Education that a primary function of the Township of Union Public School System is formulation of a learning climate conducive to the needs of all students in general, providing therein for individual differences. The school operates as a partner with the home and community.

Statement of District Goals

- Develop reading, writing, speaking, listening, and mathematical skills.
- Develop a pride in work and a feeling of self-worth, self-reliance, and self discipline.
- Acquire and use the skills and habits involved in critical and constructive thinking.
- Develop a code of behavior based on moral and ethical principals.
- To be able to work with others cooperatively.
- Acquire a knowledge and appreciation of the historical record of human achievement and failures and current societal issues.
- Acquire a knowledge and understanding of the physical and biological sciences.
- Efficient and effective participation in economic life and the development of skills to enter a specific field of work.
- Appreciate and understand literature, art, music, and other cultural activities.
- Develop an understanding of the historical and cultural heritage.
- Develop a concern for the proper use and/or preservation of natural resources.
- Develop basic skills in sports and other forms of recreation.

UHS Environmental Science CURRICULUM

Course Description

The Environmental course is designed as a science elective, to fulfill the third year science requirement, or for students wishing to take an additional science course during their senior year. The course is inquiry based and utilizes laboratory investigations, internet research, and projects, to develop science knowledge that will be interesting and applicable to the student seeking to gain a greater understanding of environmental issues, as well as human impact on the environment. In addition, students will develop skills such as: identifying problems; forming hypotheses; data collection & data analysis; and making inferences. The curriculum introduces relevant topics in studies of the study of earth's resources and pollution; human populations and their impact; renewable and non-renewable energy sources; and climate change. These topics have been aligned with the New Generation Science Standards.

Goal

The goal of Environmental Science is to produce students that have a basic understanding of their environment, relevant to their lives, and to understand causes and effects of the impact of human activities on the earth.

Recommended Textbooks

Withgott, Jay. (2011). Environmental Science. Pearson, Upper Saddle River, New Jersey.

UHS Environmental Science CURRICULUM

Course Proficiencies

Students will be able to...

1. Improve writing skills through comprehensive written lab reports.
2. Differentiate the steps of the Scientific Method and utilize it as a model for all types of problem solving especially by conducting experiments and performing labs in effective collaborative groups.
3. Utilize mathematical skills, including measuring, using the metric system, performing calculations, interpreting formulas, graphing, and data analysis.
4. Assess the economics & policy that has been put in place to govern human use of the environment
5. Display an understanding of soil, agriculture, and food use, production, and impact.
6. Explore how forestry is integral in everyday life and ways to use it sustainably.
7. Identify the role that minerals play in human production and the impact that mining can cause.
8. Display an understanding of water resources, their supply, usage, and pollution.
9. Research and define what biodiversity is and how its role is integrated in the ecology of the world.
10. Develop a basic understanding of the atmosphere, how it's impacted and the conditions that are a direct result of humans.
11. Explore how human populations are changing and its relation to a nation's ecological footprint.
12. Understand how land is being used and the growing urbanization trend seen worldwide.
13. Assess the state of environmental health and toxicology of the natural resources humans use.
14. Identify the forms of waste produced by humans, their potential hazards, and clean up.
15. Understand the impact that climate change has on our planet. Relate cause and effect of climate change and meteorological trends.
16. Display an understanding of non-renewable energy, its limits, conservation, and its impacts
17. Explore renewable energy, its future, limits, and its potential impacts.
18. Explore ways of reducing our carbon footprint.

UHS Environmental Science CURRICULUM

Pacing Guide- Course

<u>Content</u>	<u>Number of Days</u>
<u>Unit 1:</u> Defining Environmental Science	30
<u>Unit 2:</u> Study of Resources	60
<u>Unit 3:</u> Human Populations & Impacts	45
<u>Unit 4:</u> Atmosphere & Climate Change & Energy	45

UHS Environmental Science CURRICULUM

CONTENT AREA: Environmental Science	Grade: HS	UNIT #: 1	UNIT NAME: Defining Environmental Science
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<u>Unit 1 Defining Environmental Science</u>		CORRESPONDING PE
#	STUDENT LEARNING OBJECTIVES	
	<p>This unit will explain the unintended consequences of harvesting natural resources from an ecosystem. The student will compare over time the impact of human activity on the cycling of matter and energy through ecosystems. The student will 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). Students will define how policy, law, and economics pertain to Environmental Science.</p>	
1	<p>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.]</p>	HS-ESS3-1
2	<p>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.]</p>	HS-ESS3-3
3	<p>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).]</p>	HS-ESS3-4

UHS Environmental Science CURRICULUM			
CONTENT AREA: Environmental Science	Grade: HS	UNIT #: 1	UNIT NAME: Defining Environmental Science
4	<p>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.]</p>		HS-ESS3-6

UHS Environmental Science CURRICULUM

CONTENT AREA: Environmental Science

Grade: HS

UNIT #: 1

UNIT NAME: Defining Environmental Science

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

- 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-ESS3-3)
- (HS-ESS-4). (HS-ESS-6)
- 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

Disciplinary Core Ideas

- 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-ESS3-1). (HS-ESS3-4)
- 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)
- 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)

Crosscutting Concepts

- Stability and Change (pp. 98-101)
 - 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)
- Cause and Effect (pp. 87-89)
 - 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)
- Connections to Engineering, Technology, and Applications of Science
 - Influence of Science, Engineering, and Technology on Society and the Natural World
 - Modern civilization depends on major technological systems. (HS-ESS3-1). (HS-ESS3-3)
 - Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to

UHS Environmental Science CURRICULUM

CONTENT AREA: Environmental Science

Grade: HS

UNIT #: 1

UNIT NAME: Defining Environmental Science

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, ethical considerations). (HS-ESS3-4)

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)

increase benefits while decreasing costs and risks. (HS-ESS3-3), (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)

Connections to Nature of Science

Science is a Human Endeavor

- Science is a result of human endeavors, imagination, and creativity. (HS-ESS3-3)

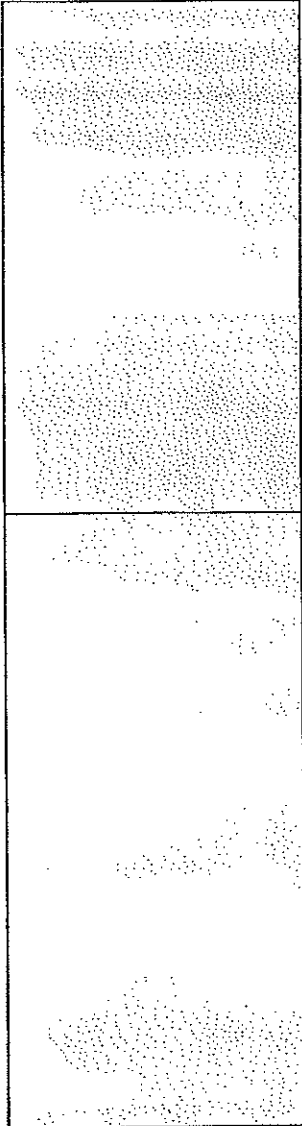
Science Addresses Questions About the Natural and Material World

- Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-4)
- 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-ESS3-4)
- Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-4)

UHS Environmental Science CURRICULUM

CONTENT AREA: Environmental Science **Grade: HS** **UNIT #: 1** **UNIT NAME: Defining Environmental Science**

- 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-ESS3-5)



UHS Environmental Science CURRICULUM

CONTENT AREA: Environmental Science **Grade:** HS **UNIT #: 1** **UNIT NAME:** Defining Environmental Science

Connections to other DCIs in this grade-band:

HS.PS1.B (HS-ESS3-3); HS.LS2.A (HS-ESS3-3); HS.LS2.B (HS-ESS3-3), (HS-ESS3-6); HS.LS2.C (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6); HS.LS4.D (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6); HS.ESS2.A (HS-ESS3-3), (HS-ESS3-6); HS.ESS2.E (HS-ESS3-3)

Common Core State Standards Connections:

ELA/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-ESS3-1), (HS-ESS3-4)

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-ESS3-4)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-ESS3-1), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6)

MP.4 Model with mathematics. (HS-ESS3-3), (HS-ESS3-6)

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-ESS3-1), (HS-ESS3-4), (HS-ESS3-6)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6)

UHS Environmental Science CURRICULUM

CONTENT AREA: Environmental Science	Grade: HS	UNIT #: 1	UNIT NAME: <u>Defining Environmental Science</u>
<u>Sample Activities, Lessons, and Lab</u>			
Define and Explore the Community of Science (Environmental Science Txt Section 1-2)			
Explore and correlate the community of science to the Nature of Science (Environmental Science Txt Section 1-3)			
Define and differentiate the types of Environmental Economics (Environmental Science Txt Section 2-1)			
Research and explore the Environmental Policy of the United States (Environmental Science Txt Section 2-2)			
Research and explore International Policy and how it correlates and influences the United States (Environmental Science Txt Section 2-3)			
Model and explain the concept of the Tragedy of the Commons			
Examine examples and model the concept of Carrying Capacity, Non-Renewable Energy, and Renewable Energy			
LAB: Perform observations of the environment Lab and examine observations of the environment			
LAB: Carry out a research lab with measurements and calculations of the Ecological Footprints of various countries			
LAB: Examine and Model the Tragedy of the commons lab with beans and spoons to simulate fishing resources			
LAB: Pearson's Ch 2 Working Trees Lab to Model how policy can affect economic savings with tree placement when building or planting			
LAB: Pearson's Choose an Approach when students examine, define, and determine the proper Environmental policy approach to a problem			
LAB: Pearson's Pending Law Lab where student research and determine the proper follow up for a pending Environmental Law			

UHS Environmental Science CURRICULUM

UHS Environmental Science		Grade: HS	UNIT #: 2	UNIT NAME: Unit 2: Study of Resources
<u>Unit 2: Study of the Terrestrial Ecosystem</u>				
<ul style="list-style-type: none"> • This unit will explain the unintended consequences of harvesting natural resources from an ecosystem. The student will compare over time the impact of human activity on the cycling of matter and energy through the natural resources of; Soil & Agriculture, Forestry, Minerals, Water, and Biodiversity. • The student will assess (using scientific, economic, and other data) the potential environmental impact of <ul style="list-style-type: none"> • The role humans undertake in agriculture, livestock raising, and food production, its impact and possible sustainability concepts • how forestry is integral in everyday life and ways to use it sustainably. • Identifying the role that minerals play in human production and the impact that mining can cause. • Display an understanding of water resources, their supply, usage, and pollution. • The use and conservation of biodiversity resources and how their use plays an essential role in human health 				
#	STUDENT LEARNING OBJECTIVES	CORRESPONDING PE		
1	<p>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.]</p>	HS-ESS3-1		
2	<p>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.]</p>	HS-ESS3-2		
3	<p>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.]</p>	HS-ESS3-3		

UHS Environmental Science CURRICULUM

CONTENT AREA: Environmental Science		Grade: HS	UNIT #: 2	UNIT NAME: Unit 2: Study of Resources
4	<p>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).]</p>			HS-ESS2-5
5	<p>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.]</p>			HS-LS2-1
6	<p>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.]</p>			HS-LS2-2
7	<p>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.]</p>			HS-LS2-7
8	<p>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.]</p>			HS-LS4-6

UHS Environmental Science CURRICULUM

CONTENT AREA: Environmental Science		Grade: HS	UNIT #: 2	UNIT NAME: Unit 2: Study of Resources
9	<p>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).]</p>			HS-ESS3-4
10	<p>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.] <i>[Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]</i></p>			HS-ESS3-6
11	<p>Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.</p>			HS-ETS1-1
12	<p>Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.</p>			HS-ETS1-2
13	<p>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.</p>			HS-ETS1-3

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UNIT NAME: Unit 2: Study of Resources

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

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-ESS3-3), (HS-ESS3-4), (HS-ESS3-6)

Asking Questions and Defining Problems

Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)

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-

Disciplinary Core Ideas

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-ESS3-5)

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)

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)

LS2.A: Interdependent Relationships in Ecosystems

- 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

Crosscutting Concepts

Scale, Proportion, and Quantity

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1)
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2)

Stability and Change (pp. 98-101)

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-7)
- 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-ESS3-3)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)

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)

Cause and Effect (pp. 87-89)

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1), (HS-LS4-6)

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<p>ESS3-3)</p> <ul style="list-style-type: none"> Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (HS-LS2-1) Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2) Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6) <p>Planning and Carrying Out Investigations</p> <p>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.</p> <ul style="list-style-type: none"> 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) <p>Constructing Explanations and Designing Solutions</p> <p>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.</p> <ul style="list-style-type: none"> 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 	<p>such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environmental and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1), (HS-LS2-2)</p> <p>LS2.C: Ecosystem Dynamics, Functioning, and Resilience</p> <ul style="list-style-type: none"> 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. (HS-LS2-2) 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. (HS-LS2-7) <p>LS4.D: Biodiversity and Humans</p> <ul style="list-style-type: none"> Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HS-LS2-7) 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 	<p>Systems and System Models</p> <ul style="list-style-type: none"> 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) <p>Connections to Engineering, Technology, and Applications of Science</p> <p>Influence of Science, Engineering, and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> Modern civilization depends on major technological systems. (HS-ESS3-1), (HS-ESS3-3) Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices 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), (HS-ETS1-1), (HS-ETS1-3) Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2) <p>Connections to Nature of Science</p> <p>Science is a Human Endeavor</p> <ul style="list-style-type: none"> Science is a result of human endeavors, 	

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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)
- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-LS2-7)
- 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)

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, ethical considerations). (HS-ESS3-6)

supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary to HS-LS2-7)
(Note: This *Disciplinary Core Idea* is also addressed by HS-LS4-6.)

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)

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,

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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<p><u>Connections to Nature of Science</u> Scientific Knowledge is Open to Revision in Light of New Evidence</p> <ul style="list-style-type: none"> Most scientific knowledge is quite durable, but is in principle subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-2) 	<p>and environmental impacts. (HS-ETS1-1), (secondary to HS-ESS3-2), (secondary HS-ESS3-4), (secondary to HS-LS2-7)</p> <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> 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)
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Connections to other DCIs in this grade-band:

HS.PS1.A (HS-ESS2-5), **HS.PS1.B** (HS-ESS2-5), (HS-ESS3-3); **HS.PS3.B** (HS-ESS2-5), (HS-ESS3-2); **HS.LS2.A** (HS-ESS3-2), (HS-ESS3-3); **HS.LS2.B** (HS-ESS3-2), (HS-ESS3-3); **HS.LS2.C** (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6); **HS.LS4.D** (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6); **HS.ESS2.A** (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-6); **HS.ESS2.E** (HS-ESS3-3), (HS-LS4); **HS.ESS2.D** (HS-LS2-7), (HS-LS4); **HS.ESS3.A** (HS-ESS3-3), (HS-ESS3-6); **HS.ESS3.C** (HS-ESS2-5), (HS-LS4-6); **HS.ESS3.D** (HS-LS2-2), (HS-LS4-6)

Common Core State Standards Connections:

ELA/Literacy -

- RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-7)
- 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-ESS3-1), (HS-ESS3-2), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2)
- 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-LS2-7), (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-ESS3-2), (HS-ESS3-4), (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-ESS3-1), (HS-LS2-

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1), (HS-LS2-2)

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-LS4-6)

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-LS2-7), (HS-LS4-6), (HS-ESS2-5)

Mathematics -

MP.2

Reason abstractly and quantitatively. (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2), (HS-ETS1-1), (HS-ETS1-3)

MP.4

Model with mathematics. (HS-ESS3-3), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2), (HS-ETS1-1), (HS-ETS1-2), (HS-ETS1-3)

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-ESS3-1), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2), (HS-LS2-7)

HSN.Q.A.2

Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2), (HS-LS2-7)

HSN.Q.A.3

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2), (HS-LS2-7), (HS-ESS2-5)

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CONTENT AREA: Environmental Science	Grade: HS	UNIT #: 2	UNIT NAME: Unit 2: Study of Resources
<u>Sample Activities, Lessons, and Lab</u>			
Define and Explore the importance and methods of forestry and conserving tree resources (Environmental Science Txt Chapter 11)			
Explore, Research, and Define the importance of Biodiversity resources and how humans can benefit from them and our impact (Env Sci Text Chapter 7)			
Explore and define the methods of soil resources, how its studied, and how it can be conserved (Environmental Science Txt Section 12-1 and 12-2)			
Correlate proper environmental methods for Agriculture and food production with soil resources (Environmental Science Txt Section 12-3 & 12-4)			
Define and differentiate the process of mining and what mining regulations and impacts are (Environmental Science Txt Chapter 13)			
Detail and explore the use and impact of Water Resources (Environmental Science Txt Chapter 14)			
Examine examples and model the impact of humans on the atmosphere and what the results are from air pollution (Environmental Science Txt Chapter 15)			
LAB: Pearson National Forest Lab allows students to research and design their own National Forest based on resources and policies of National Forests			
LAB: Pearson Working Lumber Lab where students calculate how many boards for building can be gained from a tree based on width and height			
LAB: Students can examine, record, and display local species from different taxonomic classes and make a Biodiversity Log using internet research			
LAB: Pearson Soil Classification Lab where students identify soil samples to type with a dichotomous key and hands on testing			
LAB: Pearson Planting Data Lab where students examine times and frost dates and plan a garden or crop based on a pre-determined sized area			
LAB: Students research online the cost of food and the environmental impact of eating imported foods			
LAB: Pearson Local Geology Lab where students research what minerals are found locally and then sample rocks found locally			
LAB Water testing lab where students test for major pollutants that are present in water			
LAB Students use index cards or petri dishes to sit out with Vaseline to sample particulate matter outside over a period of 24 hours			

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CONTENT AREA: Environmental Science	Grade: HS	UNIT #: 3	UNIT NAME: Unit 3: Human Population & Impact
<u>Unit 3 Human Population & Impact</u>			
<ul style="list-style-type: none"> • This unit will explain the unintended consequences of an ever growing human population and its impact on the environment. The student will compare over time the impact of human activity through, Human Population Growth, Environmental Policy & Economics, Land Use & Urbanization, Human Health & Toxicology, and waste produced by humans. • The student will assess, explore, understand, address, and identify (using scientific, economic, and other data) the potential environmental impact of; <ul style="list-style-type: none"> • how human populations are changing and its relation to a nation's ecological footprint. • how land is being used and the growing urbanization trend seen worldwide. • the state of environmental health and toxicology of the natural resources humans use. • the forms of waste produced by humans, their potential hazards, and clean up. 			
#	STUDENT LEARNING OBJECTIVES		
1	<p>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.]</p>		
	HS-ESS3-1		
2	<p>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.]</p>		
	HS-ESS3-3		
3	<p>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</p>		
	HS-ESS3-4		

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UHS Environmental Science CURRICULUM		Grade: HS	UNIT #: 3	UNIT NAME: Unit 3: Human Population & Impact
CONTENT AREA: Environmental Science				
	changes to the atmosphere or ocean).]			
4	<p>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.]</p>	HS-ESS3-6		
5	<p>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.]</p>	HS-LS2-1		
6	<p>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.]</p>	HS-LS2-2		
7	<p>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.]</p>	HS-LS2-7		
8	<p>Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.</p>	HS-ETS1-1		
9	<p>Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.</p>	HS-ETS1-2		

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CONTENT AREA: Environmental Science

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UNIT NAME: Unit 3: Human Population & Impact

10 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

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- Analyze data using computational models in order to make valid and reliable scientific claims. (HS-ESS3-3), (HS-ESS3-4), (HS, ESS3-6)

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Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

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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.

Disciplinary Core Ideas

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LS2.A: Interdependent Relationships in Ecosystems

- 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 environmental and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given

Crosscutting Concepts

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- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)

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- 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)

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CONTENT AREA: Environmental Science **Grade:** HS **UNIT #:** 3 **UNIT NAME:** Unit 3: Human Population & Impact

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-ESS3-3)
- Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (HS-LS2-1)
- Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2)
- 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)
- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge,

ecosystem. (HS-LS2-1), (HS-LS2-2)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- 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. (HS-LS2-2)
- 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. (HS-LS2-7)

LSA.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HS-LS2-7)
- 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. (secondary to HS-LS2-7)

(Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)

Connections to Engineering, Technology, and Applications of Science

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

- Modern civilization depends on major technological systems. (HS-ESS3-1), (HS-ESS3-3)
- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-ESS3-4)
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3), (HS-ETS1-1), (HS-ETS1-3)
- Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-3)

Connections to Nature of Science

Science is a Human Endeavor

- Science 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-ESS3-3)
- Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human

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<p>student-generated sources of evidence; prioritized criteria, and tradeoff considerations. (HS-LS2-7)</p> <ul style="list-style-type: none"> 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) <p>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.</p> <ul style="list-style-type: none"> 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-ESS3-6) <hr/> <p>Connections to Nature of Science Scientific Knowledge is Open to Revision in Light of New Evidence</p> <ul style="list-style-type: none"> Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-2) 	<p>ESS3.B: Natural Hazards</p> <ul style="list-style-type: none"> 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) <p>ESS3.C: Human Impacts on Earth Systems</p> <ul style="list-style-type: none"> 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) <p>ETS1.A: Defining and Delimiting Engineering Problems</p> <ul style="list-style-type: none"> 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) <p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> 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), (secondary HS-ESS3-4), (secondary to HS-LS2-7) <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about 	<p>decisions about the use of knowledge. (HS-ESS3-3)</p> <ul style="list-style-type: none"> Many decisions are not made using science alone; but rely on social and cultural contexts to resolve issues. (HS-ESS3-3) 	

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<p>the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)</p>			
<p><i>Connections to other DGIs in this grade-band:</i></p> <p>HS.PS1.B (HS-ESS3-3); HS.LS2.A (HS-ESS3-3); HS.LS2.B (HS-ESS3-3); HS.LS2.C (HS-ESS3-3); HS-ESS3-4; HS-ESS3-6; HS.LS4.D (HS-ESS3-3); HS-ESS3-4; HS-ESS3-6; HS.ESS2.A (HS-ESS3-3); HS-ESS3-6; HS.ESS2.D (HS-LS2-7); HS-LS4-6; HS.ESS2.E (HS-ESS3-3)</p> <p><i>Common Core State Standards Connections:</i></p> <p>ELA/Literacy -</p> <p>RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-7)</p> <p>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-ESS3-1); (HS-ESS3-4); (HS-LS2-1); (HS-LS2-2)</p> <p>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-LS2-7); (HS-ETS1-1); (HS-ETS1-3)</p> <p>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-ESS3-3); (HS-ESS3-4); (HS-LS2-7); (HS-ETS1-1); (HS-ETS1-3)</p> <p>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)</p> <p>WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1); (HS-LS2-1); (HS-LS2-2)</p> <p>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-LS2-7)</p> <p><i>Mathematics -</i></p>			

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- MP.2 Reason abstractly and quantitatively. (HS-ESS3-1), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2), (HS-ETS1-1), (HS-ETS1-3)
- MP.4 Model with mathematics. (HS-ESS3-3), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2), (HS-ETS1-1), (HS-ETS1-2), (HS-ETS1-3)
- 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-ESS3-1), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2), (HS-LS2-7)
- HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2), (HS-LS2-7)
- HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6), (HS-LS2-1), (HS-LS2-2), (HS-LS2-7)

Sample Activities, Lessons, and Lab

Define and Research how Human Populations are structured and how they may be growing (Environmental Science Txt Chapter 8)

Explore and define what environmental health is (Environmental Science Txt Section 9-1)

Define and differentiate between toxicology and epidemiology (Environmental Science Txt Section 9-2 and 9-3)

Research and explore how natural disasters impact human health, environment, society, and economics (Environmental Science Txt Section 9-4)

Define and explore Land Use and Urbanization in the United States (Environmental Science Txt Section 10-1)

Research and model how sprawl is spreading through urbanized areas of the United States (Environmental Science Txt Section 10-2)

Examine, Research, and model how to build sustainable cities (Environmental Science Txt Section 10-3)

LAB: Pearson's Age, Sex Population Graph Lab of two different countries

LAB: Pearson's Census Lab where students examine the change in the community over the course of 10 years

LAB: Students will research and present how the Superfund program was created and what sites are within our county

LAB: Students will trace an outbreak of a disease and try to determine where it began and under what environmental conditions

LAB: Students will research what chemicals are present in their home and how toxic they are according to the online MSDS

LAB: Students will analyze a map of the city of UNION and determine how land is used and if Sprawl is present

LAB: Students will create and model a community from the ground up as a land planning community would.

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	<p><u>Unit 4 Atmosphere & Climate Change & Energy</u></p>	
	<ul style="list-style-type: none"> • This unit will explain the unintended consequences of an the effect of human technology and energy production, its by-products, and its impact on the environment. The student will compare over time the impact of human activity through; the Atmosphere and pollution, Climate Change, Non-Renewable Energy, Renewable Energy, and waste produced by humans. • The student will assess, explore, understand, address, and identify (using scientific, economic, and other data) the potential environmental impact of: <ul style="list-style-type: none"> • How human technology has added and impacted the atmosphere and air with areas of high concentration. • Understand the impact that climate change has on our planet. Relate cause and effect of climate change and meteorological trends. • Display an understanding of non-renewable energy, its limits, conservation, and its impacts • Explore renewable energy, its future, limits, and its potential impacts. 	

	STUDENT LEARNING OBJECTIVES	CORRESPONDING PE
#		
1	<p>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.]</p>	HS-ESS2-2
2	<p>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.]</p>	HS-ESS2-3
3	<p>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.] <i>[Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface</i></p>	HS-ESS2-4

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CONTENT AREA: Environmental Science		Grade: HS	UNIT #: 4	UNIT NAME: <u>Unit 4: Atmosphere & Climate</u> <u>Change & Energy</u>
4	<p><i>temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]</i></p> <p>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.]</p>	HS-ESS3-1		
5	<p>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.]</p>	HS-ESS3-3		
6	<p>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).]</p>	HS-ESS3-4		
7	<p>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.]</p>	HS-ESS3-5		

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8	<p>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.] <i>[Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]</i></p>			HS-ESS3-6
9	<p>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.]</p>			HS-LS2-7
10	<p>Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.</p>			HS-ETS1-1
11	<p>Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.</p>			HS-ETS1-2
12	<p>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.</p>			HS-ETS1-3
<p>The performance expectations above were developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i>:</p>				
<p>Science and Engineering Practices</p> <p>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.</p> <ul style="list-style-type: none"> Analyze data using computational models in order to make valid and reliable scientific claims. (HS-ESS2-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6) 		<p>Disciplinary Core Ideas</p> <p>ESS2.A: Earth Materials and Systems</p> <ul style="list-style-type: none"> Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2) 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 		<p>Crosscutting Concepts</p> <p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1) Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2) <p>Stability and Change (pp. 98-101)</p> <ul style="list-style-type: none"> Much of science deals with constructing

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<p>Asking Questions and Defining Problems</p> <p>Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.</p> <ul style="list-style-type: none"> Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) <p>Developing and Using Models</p> <p>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 worlds).</p> <ul style="list-style-type: none"> Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3) Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4) <p>Using Mathematics and Computational Thinking</p> <p>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, exponential 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.</p> <ul style="list-style-type: none"> Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-ESS3-3) 	<p>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)</p> <p>ESS2.D: Weather and Climate</p> <ul style="list-style-type: none"> Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6), (HS-ESS2-4) 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) LS2.A: Interdependent Relationships in Ecosystems 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 	<p>explanations of how things change and how they remain stable. (HS-LS2-7)</p> <ul style="list-style-type: none"> 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), (HS-ESS3-5) Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2), (HS-ESS3-4) Cause and Effect (pp. 87-89) Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4), (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) <p>Connections to Engineering, Technology, and Applications of Science</p> <p>Interdependence of Science, Engineering, and Technology</p> <ul style="list-style-type: none"> 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-ESS2-3) Influence of Science, Engineering, and Technology on Society and the Natural World 	

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<ul style="list-style-type: none"> • Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (HS-LS2-1) • Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2) • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6) <p>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.</p> <ul style="list-style-type: none"> • 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) • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized 	<p>tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1), (HS-LS2-2)</p> <p>LS2.C: Ecosystem Dynamics, Functioning, and Resilience</p> <ul style="list-style-type: none"> • 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. (HS-LS2-2) • 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. (HS-LS2-7) <p>LS4.D: Biodiversity and Humans</p> <ul style="list-style-type: none"> • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HS-LS2-7) • 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 	<ul style="list-style-type: none"> • Modern civilization depends on major technological systems. (HS-ESS3-1), (HS-ESS3-3) • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-ESS3-4) • New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS2-2), (HS-ESS3-3), (HS-ETS1-1), (HS-ETS1-3) • Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-3) <p style="text-align: center;">Connections to Nature of Science</p> <p>Science is a Human Endeavor</p> <ul style="list-style-type: none"> • Science is a result of human endeavors, imagination, and creativity. (HS-ESS3-3) <p>Science Addresses Questions About the Natural and Material World</p> <ul style="list-style-type: none"> • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-3) • 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-ESS3-3) • Many decisions are not made using science 	

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CONTENT AREA: Environmental Science	Grade: HS	UNIT #: 4	UNIT NAME: <u>Unit 4: Atmosphere & Climate Change & Energy</u>
<p>criteria, and tradeoff considerations. (HS-LS2-7)</p> <ul style="list-style-type: none"> • 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) <p>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.</p> <ul style="list-style-type: none"> • 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-ESS3-6) <hr/> <p style="text-align: center;"><i>Connections to Nature of Science</i></p> <p>Scientific Knowledge is Open to Revision in Light of New Evidence</p> <ul style="list-style-type: none"> • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-2) <hr/> <p style="text-align: center;"><i>Connections to Nature of Science</i></p> <p>Scientific Knowledge is Based on Empirical Evidence</p>	<p>recreational or inspirational value. (secondary to HS-LS2-7) (Note: This <i>Disciplinary Core Idea</i> is also addressed by HS-LS4-6.)</p> <p>ESS3.B: Natural Hazards</p> <ul style="list-style-type: none"> • 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) <p>ESS3.C: Human Impacts on Earth Systems</p> <ul style="list-style-type: none"> • 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) <p>ESS3.D: Global Climate Change</p> <ul style="list-style-type: none"> • 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) <p>ETS1.A: Defining and Delimiting Engineering Problems</p> <ul style="list-style-type: none"> • 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) 	<p>alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-3)</p>	

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<ul style="list-style-type: none"> • Science knowledge is based on empirical evidence. (HS-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) • Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4) <p style="text-align: center; border-top: 1px dashed black; margin-top: 10px;"> Connectors to Nature of Science </p> <p>Scientific Investigations Use a Variety of Methods</p> <ul style="list-style-type: none"> • 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) <p>Scientific Knowledge is Based on Empirical Evidence</p> <ul style="list-style-type: none"> • 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) 	<p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> • 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), (secondary HS-ESS3-4); (secondary to HS-LS2-7) <p>ETS1.C: Optimizing the Design Solution</p> <ul style="list-style-type: none"> • 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) 	<p>HS.PS1.B (HS-ESS3-3); HS.PS2.B (HS-ESS2-1), (HS-ESS2-3); HS.PS3.A (HS-ESS2-4); HS.PS3.B (HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-3), (HS-ESS3-6); HS.PS4.B (HS-ESS2-2); HS.LS1.C (HS-ESS3-5); HS.LS2.A (HS-ESS3-5); HS.LS2.B (HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS3-4), (HS-ESS3-6); HS.LS4.D (HS-ESS2-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6); HS.ESS2.E (HS-ESS3-3); HS.ESS3.C (HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-5), (HS-ESS2-6), (HS-ESS2-7), (HS-ESS2-8), (HS-ESS2-9), (HS-ESS2-10), (HS-ESS2-11), (HS-ESS2-12), (HS-ESS2-13), (HS-ESS2-14), (HS-ESS2-15), (HS-ESS2-16), (HS-ESS2-17), (HS-ESS2-18), (HS-ESS2-19), (HS-ESS2-20), (HS-ESS2-21), (HS-ESS2-22), (HS-ESS2-23), (HS-ESS2-24), (HS-ESS2-25), (HS-ESS2-26), (HS-ESS2-27), (HS-ESS2-28), (HS-ESS2-29), (HS-ESS2-30), (HS-ESS2-31), (HS-ESS2-32), (HS-ESS2-33), (HS-ESS2-34), (HS-ESS2-35), (HS-ESS2-36), (HS-ESS2-37), (HS-ESS2-38), (HS-ESS2-39), (HS-ESS2-40), (HS-ESS2-41), (HS-ESS2-42), (HS-ESS2-43), (HS-ESS2-44), (HS-ESS2-45), (HS-ESS2-46), (HS-ESS2-47), (HS-ESS2-48), (HS-ESS2-49), (HS-ESS2-50), (HS-ESS2-51), (HS-ESS2-52), (HS-ESS2-53), (HS-ESS2-54), (HS-ESS2-55), (HS-ESS2-56), (HS-ESS2-57), (HS-ESS2-58), (HS-ESS2-59), (HS-ESS2-60), (HS-ESS2-61), (HS-ESS2-62), (HS-ESS2-63), (HS-ESS2-64), (HS-ESS2-65), (HS-ESS2-66), (HS-ESS2-67), (HS-ESS2-68), (HS-ESS2-69), (HS-ESS2-70), (HS-ESS2-71), (HS-ESS2-72), (HS-ESS2-73), (HS-ESS2-74), (HS-ESS2-75), (HS-ESS2-76), (HS-ESS2-77), (HS-ESS2-78), (HS-ESS2-79), (HS-ESS2-80), (HS-ESS2-81), (HS-ESS2-82), (HS-ESS2-83), (HS-ESS2-84), (HS-ESS2-85), (HS-ESS2-86), (HS-ESS2-87), (HS-ESS2-88), (HS-ESS2-89), (HS-ESS2-90), (HS-ESS2-91), (HS-ESS2-92), (HS-ESS2-93), (HS-ESS2-94), (HS-ESS2-95), (HS-ESS2-96), (HS-ESS2-97), (HS-ESS2-98), (HS-ESS2-99), (HS-ESS2-100)</p>	<p><i>Connections to other DCIs in this grade-band:</i></p> <p>HS.PS1.B (HS-ESS3-3); HS.PS2.B (HS-ESS2-1), (HS-ESS2-3); HS.PS3.A (HS-ESS2-4); HS.PS3.B (HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-3), (HS-ESS3-6); HS.PS4.B (HS-ESS2-2); HS.LS1.C (HS-ESS3-5); HS.LS2.A (HS-ESS3-5); HS.LS2.B (HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS3-4), (HS-ESS3-6); HS.LS4.D (HS-ESS2-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6); HS.ESS2.E (HS-ESS3-3); HS.ESS3.C (HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-5), (HS-ESS2-6), (HS-ESS2-7), (HS-ESS2-8), (HS-ESS2-9), (HS-ESS2-10), (HS-ESS2-11), (HS-ESS2-12), (HS-ESS2-13), (HS-ESS2-14), (HS-ESS2-15), (HS-ESS2-16), (HS-ESS2-17), (HS-ESS2-18), (HS-ESS2-19), (HS-ESS2-20), (HS-ESS2-21), (HS-ESS2-22), (HS-ESS2-23), (HS-ESS2-24), (HS-ESS2-25), (HS-ESS2-26), (HS-ESS2-27), (HS-ESS2-28), (HS-ESS2-29), (HS-ESS2-30), (HS-ESS2-31), (HS-ESS2-32), (HS-ESS2-33), (HS-ESS2-34), (HS-ESS2-35), (HS-ESS2-36), (HS-ESS2-37), (HS-ESS2-38), (HS-ESS2-39), (HS-ESS2-40), (HS-ESS2-41), (HS-ESS2-42), (HS-ESS2-43), (HS-ESS2-44), (HS-ESS2-45), (HS-ESS2-46), (HS-ESS2-47), (HS-ESS2-48), (HS-ESS2-49), (HS-ESS2-50), (HS-ESS2-51), (HS-ESS2-52), (HS-ESS2-53), (HS-ESS2-54), (HS-ESS2-55), (HS-ESS2-56), (HS-ESS2-57), (HS-ESS2-58), (HS-ESS2-59), (HS-ESS2-60), (HS-ESS2-61), (HS-ESS2-62), (HS-ESS2-63), (HS-ESS2-64), (HS-ESS2-65), (HS-ESS2-66), (HS-ESS2-67), (HS-ESS2-68), (HS-ESS2-69), (HS-ESS2-70), (HS-ESS2-71), (HS-ESS2-72), (HS-ESS2-73), (HS-ESS2-74), (HS-ESS2-75), (HS-ESS2-76), (HS-ESS2-77), (HS-ESS2-78), (HS-ESS2-79), (HS-ESS2-80), (HS-ESS2-81), (HS-ESS2-82), (HS-ESS2-83), (HS-ESS2-84), (HS-ESS2-85), (HS-ESS2-86), (HS-ESS2-87), (HS-ESS2-88), (HS-ESS2-89), (HS-ESS2-90), (HS-ESS2-91), (HS-ESS2-92), (HS-ESS2-93), (HS-ESS2-94), (HS-ESS2-95), (HS-ESS2-96), (HS-ESS2-97), (HS-ESS2-98), (HS-ESS2-99), (HS-ESS2-100)</p>
<i>Common Core State Standards Connections:</i>			

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<i>ELA/Literacy -</i>			
<u>RST.9-10.8</u>	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-7)		
<u>RST.11-12.1</u>	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-ESS2-2), (HS-ESS2-3), (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-5)		
<u>RST.11-12.2</u>	Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS2-2), (HS-ESS3-5)		
<u>RST.11-12.7</u>	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-LS2-7), (HS-ESS3-5), (HS-ETS1-1), (HS-ETS1-3)		
<u>RST.11-12.8</u>	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-ESS3-3), (HS-ESS3-4), (HS-LS2-7), (HS-ETS1-1), (HS-ETS1-3)		
<u>RST.11-12.9</u>	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)		
<u>WHST.9-12.2</u>	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1)		
<u>WHST.9-12.7</u>	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-LS2-7)		
<u>SL.11-12.5</u>	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-ESS2-3), (HS-ESS2-4)		
<i>Mathematics -</i>			
<u>MP.2</u>	Reason abstractly and quantitatively. (HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS3-1), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-5), (HS-ETS1-1), (HS-ETS1-3)		
<u>MP.4</u>	Model with mathematics. (HS-ESS2-3), (HS-ESS2-4), (HS-ESS3-3), (HS-ESS3-6), (HS-ETS1-1), (HS-ETS1-2), (HS-ETS1-3)		

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<p>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-ESS2-2), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6), (HS-LS2-7)</p> <p>HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-3), (HS-ESS2-4), (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-5), (HS-LS2-7)</p> <p>HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6), (HS-LS2-7)</p>			
Sample Activities, Lessons, and Lab			
Discuss and identify the effects and processes that cause the greenhouse effect. (Environmental Science Txt Chapter 16)			
Identify the factors of the environment that show the effects of climate change: weather patterns, agriculture, sea levels (Environmental Science Txt Chp. 16)			
Define and illustrate examples of CFCs along with other greenhouse gases and discuss possible solutions and alternatives to such substances. (Environmental Science Txt Chapter 16)			
Discuss what the term energy means and brainstorm reasons we need energy to live in today's world. Explain how major sources of energy are dwindling. Discuss and demonstrate how energy conservation is important. (Environmental Science Text Chapters 17 & 18)			
Explain how fossil fuels are used to produce electricity.			
<ul style="list-style-type: none"> -Distinguish among types of coal and how much energy. -Describe how oil is extracted in different parts of the world and how it's used. -List and describe how many products are made from oil in a ppt -Describe and explain the characteristics of natural gas. (Environmental Science Txt Chapters 17) 			
Explain and predict the future of fossil fuels.			
<ul style="list-style-type: none"> -Explain the impact of fossil fuels to the environment and to people. This will be done historically and predictably. -Analyze data to determine predictions about when our fossil fuels will run out. -Explain the politics and economics of dependence of foreign countries for fossil fuels. (Environmental Science Chapter 17) 			
Discuss how nuclear energy works.			
<ul style="list-style-type: none"> -Model and explain how nuclear power plants generate energy. -Identify possible safety concerns regarding nuclear energy. (Environmental Science Chapter 17) 			
Explain the benefits and current status of renewable energy resources with presentations and models.			
<ul style="list-style-type: none"> -List alternative sources of biomass and explain how it is used (Environmental Science Chapter 18) 			

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<ul style="list-style-type: none"> -Describe and model how geothermal energy is used -Display and describe how hydropower is used and utilized. -Display, model, and explain how solar energy is used to heat buildings and generate electricity -Display, model, and explain how wind energy is used to produce electricity. (Environmental Science Chapter 18) 			
Display, model, and explain how hydrogen energy is used to produce electricity in fuel cells. (Environmental Science Chapter 18)			
Compare and contrast alternative energy sources, with emphasis on cost, renewability, and location. (Environmental Science Chapter 18)			
Evaluate the pros and cons of solar, wind, geothermal, and hydro power. (Environmental Science Chapter 18)			
LAB: Pearson's Fossil Fuel Lab allows students to research, graph, and analyze fossil fuel use in the United States			
LAB: Students will enumerate, define, and show examples of Fossil fuels and will model how it is obtained and refined			
LAB: Students will research and present how Fossil Fuel incidents impact the environment from Fracking, Oil Drilling, and Transport/Refinery accidents			
LAB: Students will design, model, and build their own Solar oven			
LAB: Students will research and process harvested algae to produce their own biofuel			
LAB: Students will design, model, and build their own wind turbine.			
LAB: Students will utilize NREL online to create their own feasible hybrid, stand-alone, or renewable power system.			