Department of Education

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New York City

6-12 Science Scope & Sequence

NYC Department of Education

6-12 Science Scope & Sequence

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Table of Contents

The New York City Department of Education

6–12 Science Scope & Sequence

Science is everywhere and our students are naturally curious, which makes them natural scientists. A strong science program helps them make sense of the physical world around them, it can explain the how and why things work, like complex systems, from the human body to our planet Earth. In our science classrooms, students can develop an understanding of the inter-dependency of living things as well as a respect for nature.

We live in a natural learning laboratory made up of a combination of unique ecosystems in which our students can connect to the nature that is all around them in city parks, gardens, green spaces, beaches, and waterways, and the amazing environment of New York City. Through inquiry approaches and project-based learning students can potentially address real-world problems in their communities and take action. Students engaged in scientific inquiry are keen observers and active explorers who pose questions, theorize, hypothesize, predict, conduct experiments, reach conclusions, and communicate their discoveries. These skills will help them develop into scientifically literate and responsible adults.

The **Enhanced NYC Science Scope & Sequence** is a revision of an earlier Scope & Sequence published in 2008. The Enhanced NYC Science Scope & Sequence includes the current NYS MST standards that all schools should continue to follow as well as new resources. The new resources include:

- An alignment to the NGSS Science and Engineering Practices and the Cross-Cutting Concepts.
- An alignment to the Common Core Learning Standards in English Language Arts and the Common Core Learning Standards in Mathematics given the relevance between the skills needed in all three disciplines (ELA, Math, and Science).
- An alignment to the Excellence in Environmental Education: Guidelines for Learning (K–12) published by the North American Association of Environmental Education to support the environmental education of NYC students and to encourage them to find innovative solutions to environmental problems and issues in their communities.
- The New York State Education Law – Article 17, Sections 809 – Instructions for the Humane Treatment of Animals and 810 – Conservation Day
- The Reference Tables that are used most often in Regents science courses are included (in the Grades 6–12 Scope & Sequence only.

The volume of science content in each grade can present some challenges. Teachers are faced with large amounts of content to be “covered” yet want to provide their students with opportunities for in-depth scientific exploration and inquiry. This issue of “depth versus breadth” will require teachers to accept that not all content is created equal. Teachers will also need to accept that it is often not possible to cover everything. The amount of content covered rarely correlates to the amount of content that students learn because students rarely retain all of the content that is taught. The challenge teachers face is how to teach enough content yet still make time for hands-on, inquiry-driven, extended learning. Teachers will need to decide which content merits deep exploration and which content merits familiarity or exposure. Teachers will need to make these decisions based on their knowledge of the content, assessments, instructional goals and, most importantly, an understanding of students’ learning needs, readiness, and interests. Teachers may need to differentiate and provide additional scaffolding and support based on individual student needs, not limited to but especially for our English language learners, students with special needs and students who are significantly below or above grade level. The Scope & Sequence can serve as a valuable resource for teachers in planning appropriate individual, group and whole class instruction. We trust that this resource will provide teachers with useful guidance, help them make important instructional decisions, and help them develop engaging science experiences for their students.

Anna Commitante
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The Enhanced Science Scope & Sequence

Background

New York State Learning Standards for Mathematics, Science, and Technology (MST)

In March of 1996 the New York State Board of Regents adopted the New York State Learning Standards for Mathematics, Science, and Technology (MST). This adoption included seven standards with four of the standards comprising the process skills and three of the standards covering specific content. *Currently, all NYC schools follow the New York State Learning Standards for Mathematics, Science, and Technology (MST) and the NYS assessments in science are developed based on these standards.* The standards are as follows:

Standard 1 – Analysis, Inquiry and Design

Standard 2 – Information Systems

Standard 3 – Mathematics

Standard 4 – Science

Standard 5 – Technology Education

Standard 6 – Interconnectedness: Common Themes

Standard 7 – Interdisciplinary Problem Solving

The New York State Education Department followed with the development of Core Curriculum resource guides in Elementary level Science (Grades K–4), Intermediate level Science (Grades 5-8) and Commencement level Science (Grades 9–12) in Chemistry, Earth Science, Living Environment and Physics. The core curriculum resource guides consist of the content standards, the key ideas and the performance indicators with major understandings.

MST Process Skills Standards

The MST Standards 1, 2 and 6, 7 are considered the process standards and are shared across the three content areas of mathematics, science, and technology.

Process skills are vital in understanding the natural phenomena that is science. Scientific discovery is built on such process skills as comparing and contrasting, creating models, using measurement and interpreting data, and making predictions and informed decisions.

NOTE: MST Standard 1—Analysis, Inquiry and Design, is not listed in any of the units in this Science Scope & Sequence. This standard should be included in all of the units and therefore listing this in each of the individual units would be redundant.

Next Generation Science Standards

In 2012, the National Research Council published Frameworks for K–12 Science Education. This research-based document outlined a plan of action for science education that included the 21st Century skills needed by students. The Next Generation Science Standards were developed from the Frameworks document through the collaboration of Achieve, the National Research Council the National Science Teachers Association and the American Association for the Advancement of Science. After the release of drafts and two public feedbacks, the Next Generation Science Standards were released in April, 2013.

New York State was one of the 26 states that supported the writing of the NGSS. For the adoption of the NGSS, each state must create legislation to adopt and implement the Next Generation Science Standards with state funding. To date, 13 states have adopted the Next Generation Science Standards but New York has not done so.

In March 2014, the Board of Regents discussed the quantitative feedback that was collected from a statewide survey. Respondents rated the NGSS statistically higher in 11 out of 21 criteria and rated the current New York State Science Learning Standards (NYSSLS) statistically higher in 6 out of 21 criteria. There are four criteria where the differences between the NGSS rating and the NYSSLS rating were not statistically significant. Further analysis of the quantitative data shows that both sets of standards have strengths and weaknesses when compared to the set of criteria used in the survey. *At this time, the NYS Board of Regents has not decided to adopt the NGSS. In anticipation of a NYS adoption of the NGSS or a state version of the NGSS and to help NYC educators develop an awareness of the NGSS, this enhanced version of the Science Scope & Sequence includes an alignment to the NGSS Science and Engineering Practices and the Cross-Cutting Concepts.*

These standards, and several supporting documents explaining the structure of the NGSS and a number of appendices, are accessible online at http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Practices in Science and Engineering

Due to the nature of science and its direct real-world applications, it is not possible to assess students' understanding of core ideas separately from their abilities to use the practices of science and engineering. Students must show that they know science concepts through their investigations of the natural world, the practices of science inquiry and by solving meaningful problems through the practices of engineering design.

The eight practices of science and engineering that the *Framework* identifies as essential for all students to learn and describe in detail are listed below:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Cross-Cutting Concepts

There are three major dimensions through which science education should be constructed: e built around three major dimensions:

- **a.** scientific and engineering practices
- **b.** crosscutting concepts that unify their common application across fields
- **c.** core ideas in the major disciplines of natural science

Within these dimensions are the cross-cutting practices that connect and unite the core ideas:

1. Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

2. Cause and effect. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

3. Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

4. Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

5. Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

6. Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

7. Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Common Core Learning Standards

National Standards in the areas of Mathematics and English Language Arts did not exist in the United States. In a joint effort, the National Governors Association and the Chief State School Officers partnered with Achieve, ACT and the College Board to begin work on the Common Core State Initiative. This state-led process that involved working with national experts developed a common core of state standards in English Language Arts and mathematics for Grades K–12.

In April 2009, New York State Governor David Paterson and former Education Commissioner Richard P. Mills, along with fifty other states and territories, agreed to participate in discussions concerning the development of these voluntary standards. The first draft of the standards was released for public feedback in 2009 and a second round of public feedback was taken in March of 2010. In June 2010, the final version of the Common Core State Standards (CCSS) for Mathematics and English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects were made accessible to the public. The Common Core State Standards were tied to *Race to the Top* funding and many states adopted them immediately. The New York State Board of Regents adopted the CCSS for Mathematics and CCSS for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects in July 2010.

The goal of the English Language Arts and Literacy Common Core State Standards is to make certain that students are college and career ready in the areas of reading, writing, speaking and listening. In science, students are expected to read the science texts at the grade appropriate level. They are also required to create logical argumentative writing based on claims, scientific reasoning and relevant evidence. Writing can also take the form of long-term, in-depth scientific research. In addition, academic discourse of formal and informal scientific presentations is envisaged at the grade appropriate level.

The goal of the Common Core Mathematics Standards is to make certain that students are college-and career-ready in the area of mathematics. Students are expected to solve problems and explain their thinking. Science is the application of the mathematical concepts and skills necessary for the real-world applications as presented in the science content.

This enhanced version of the Science Scope and Sequence includes an alignment to the Common Core Learning Standards in English Language Arts and Mathematics that are relevant in science.

Excellence in Environmental Education: Guidelines for Learning (K–12)

There is no exact date to point to when thinking about the history of environmental education. Some may argue that naturalists such as Thoreau and Emerson were the forefathers of the movement. However, a concerted effort to reach international agreement about the protection of the environment began in the years immediately after World War II. The *Conference for the Establishment of the International Union for the Protection of Nature* (IUCN) convened in France in October of 1948. The primary focus of this conference was to ensure the protection of nature and its habitats. The movement was slow to start until the publication of two books in the 1960s which rekindled international attention: Rachel Carson's *Silent Spring* and Steward Udall's *The Quiet Crisis*. These, along with the political climate of the 1960s, sparked United States legislation such as the Wilderness Act (1964), the Clean Air Act (1965), the Solid Waste Disposal Act (1965), and the Species Conservation Act (1966).

In 1970, the Environmental Education Act was passed as a direct result of the highly successful first Earth Day (April 22, 1970), and the office of Environmental Education was established within the U.S. Department of Education.

Excellence in Environmental Education

Environmental education builds from a core of key principles that inform its approach to education. Some of these important foundations are:

Systems: Systems help make sense of a large and complex world. A system is made up of parts. Each part can be understood separately. The whole, however, is understood only by understanding the relationships and interactions among the parts. The human body can be understood as a system; so can galaxies. Organizations, individual cells, communities of animals and plants, and families can all be understood as systems. And systems can be nested within other systems.

Interdependence: Human well-being is inextricably bound with environmental quality. Humans are a part of the natural order. We and the systems we create—our societies, political systems, economies, religions, cultures, technologies—impact the total environment. Since we are a part of nature rather than outside it, we are challenged to recognize the ramifications of our interdependence.

The importance of where one lives: Beginning close to home, learners forge connections with, explore, and understand their immediate surroundings. The sensitivity, knowledge, and skills needed for this local connection provides a base for moving out into larger systems, broader issues, and an expanding understanding of causes, connections, and consequences.

Integration and infusion: Disciplines from the natural sciences to the social sciences to the humanities are connected through the medium of the environment and environmental issues. Environmental education offers opportunities for integration and works best when infused across the curriculum, rather than being treated as a separate discipline or subject area.

Roots in the real world: Learners develop knowledge and skills through direct experience with the environment, environmental issues, and society. Investigation, analysis, and problem solving are essential activities and are most effective when relevant to the real world.

Lifelong learning: Critical and creative thinking, decision making, and communication, as well as collaborative learning, are emphasized. These skills are essential for active and meaningful learning, both in school and over a lifetime.

continued

Environmentally literate students possess the knowledge, intellectual skills, attitudes, experiences, and motivation to make and act upon responsible environmental decisions. Environmentally literate students understand environmental processes and systems, including human systems. They are able to analyze global, social, cultural, political, economic, and environmental relationships, and weigh various sides of environmental issues to make responsible decisions as individuals, as members of their communities, and as citizens of the world. (Adapted from *Maryland Partnership for Children in Nature*, April 2009)

In order to support the environmental education of NYC students and to encourage them to find innovative solutions to environmental problems and issues in their communities this enhanced version of the Science Scope & Sequence includes an alignment to the *Guidelines for Learning (K–12)* published by the North American Association of Environmental Education.

NYSED Mandated Instruction in Science New York State Education Law: Article 17, Sections 809–810

The New York State Legislature passes laws that are directly related to curriculum and instruction in the area of science. Article 17 of the New York State Education Law outlines instruction in certain subject areas. Two of the sections are directly related to science instruction. They are:

Article 17 – Section 809 pertains to the humane treatment of live vertebrate animals. Having live animals in the science classroom is encouraged because it sparks students' interest in the living world around them. The care and respect for animals and all living things must be promoted in the school setting. Section 809 of the New York State Education Law ensures that animals are treated ethically and humanely.

Article 17 – Section 810 pertains to Conservation Day which is celebrated on the last Friday in April. Conservation of the earth's natural resources is the focus of this designated day. School communities are encouraged to heighten awareness of the natural world through lectures, tours and plantings.

NOTE: Conservation Day should not be confused with Earth Day, which falls on April 22 each year.

Reference Tables (High School)

The Reference Tables are an invaluable tool to the high school science student. They contain important measurements, equations, maps, and identification tables. The booklets are frequently used during classes, tests, and lab assignments. The Reference Tables are also used on the New York State Regents Exams. Each of the Science Reference Tables is specific to the core science content that is taught. The most appropriate reference tables for the units in Chemistry, Earth Science and Physics have been selected.

Limitations and Expectations

In an effort to be concise and acknowledging that there are several options for the inclusion or absence of some of the supporting standards and guidelines, the most appropriate Mathematics Science and Technology (MST) Process Standards, Next Generation Science Standards (NGSS) Cross-Cutting Concept, Common Core Learning Standards (CCLS) in Mathematics and English Language Arts and Environmental Guidelines have been selected. Based on the discretion of the classroom teacher, other standards and tables may be seen as being appropriate for inclusion.

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NGSS Lead States. *Next Generation Science Standards: For States, By States*. Washington, DC: National Academies Press, 2013.

North American Association of Environmental Education. *Excellence in Environmental Education: Guidelines for Learning (K–12)*. Washington, DC: NAAEE Publications, 2010.

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Science Scope & Sequence Template

Grade # | Unit

Unit Title

PACING RECOMMENDATION (TIMEFRAME)

Unit Overview:

A brief teacher-friendly blurb that describes the learning in the unit at a high level. (NEW)

Essential Question:

Revised essential questions for the unit. (REVISED)

Key Ideas: The key ideas addressed throughout the unit pulled from the NYSED standards. (REVISED)

NYS SCIENCE STANDARDS http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf	**MST STANDARDS** http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf	**NGSS CROSS-CUTTING CONCEPTS** http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
State standards to be covered in the unit. Re-written to include more language directly from the standards rather than abbreviated topics in order to support teachers with being able to clearly identify what student should be able to know and do when referring to the Scope & Sequence. Feedback from the field suggests that teachers use the Scope & Sequence as their primary/sole resource when planning and often do not refer to the actual standards. (REVISED) *(Note: Items with asterisks* require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*	Identifies alignment to Standards 1, 2, 6, and 7 in order to promote consideration of the behaviors and processes students should demonstrate when engaging in scientific inquiry. (NEW)	Identified relevant cross-cutting concepts. Pulled directly from NGSS, the cross-cutting concepts help students deepen their understanding of the content and develop a coherent scientifically based view of the world. (NEW)
COMMON CORE STATE STANDARDS http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf	**ENVIRONMENTAL GUIDELINES FOR LEARNING** http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf	**REFERENCE TABLES FOR PHYSICAL SETTING CORE CONTENT**
Identifies pre-requisite or connected ELA & Math standards that align to content addressed in the unit. (NEW)	Makes clear connections between the content addressed in the unit and the environment. (NEW)	Identifies the tables that are pertinent for each of the units in Regents Chemistry, Regents Earth Science and Regents Physics. (NEW)

🍃 Leaf indicates a connection to Environmental Science

Grades
6-8

Science
Scope & Sequence

Grade 6 | Unit 1

Energy and Simple Machines

RECOMMENDED TIME: SEPTEMBER – NOVEMBER (8 WEEKS)

Unit Overview:

The study of energy will provide a better understanding about its various forms, transformations, and uses. Students should be able to design systems that will demonstrate the use and transformation of energy. As they continue exploring the concept of energy, students will know the application of potential, kinetic and mechanic energy through simple and complex machines. Students should be able to design a complex machine that will use at least one form of energy, and should be able to explain such energy transformations.

Essential Questions:

How do different forms of energy transfer and/or change matter?

In what ways can energy be effectively conserved?

How do machines use energy to do work?

What would energy-efficient machines look like?

What strategies/ideas can we pose to promote the effective use and conservation of energy?

Key Ideas:

PS. Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

PS. Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from New York State Performance Indicators (PS 4.1a - e; 4.5a, b; 5.2c-g)

- Energy cannot be created or destroyed, but only changed from one form into another. **(4.5a)**
- Energy can be considered either to be either kinetic energy, which is energy of motion, or potential energy, which depends on relative position. **(4.1e)**
- Different forms of energy include heat, light, electrical, mechanical, sound, nuclear and chemical energy. **(4.1d)**
- The Sun is a major source of energy for Earth. Other sources of energy include nuclear and geothermal energy. **(4.1a)** 🍃

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 1: Engineering Design

Key Idea 1: Engineering design is an iterative process involving modeling and optimization (finding the best solution within given constraints); this process is used to develop technological solutions to problems within given constraints.

Standard 2: Information Systems

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effectiveness and ethical use.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Scale, Proportions, and Quantity

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- The observed function of natural and designed systems may change with scale.
- Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

continued

NYS SCIENCE STANDARDS http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf	MST STANDARDS http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf	NGSS CROSS-CUTTING CONCEPTS http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
▪ Energy can change from one form to another although in the process some energy is always converted to heat. Some systems transform energy with less loss of heat than others. **(4.5b)** 🍃 ▪ Most activities in everyday life involve at least one form of energy being transformed into another. For example, the chemical energy in gasoline is transformed into mechanical energy in an automobile engine. Energy, in the form of heat, is almost always one of the products of energy transformations. **(4.1c)** 🍃 ▪ Simple machines include a lever, a pulley, a wheel and axle, and an inclined plane. **(5.2g)** ▪ A machine can be made more efficient by reducing friction. Some common ways of reducing friction include lubricating or waxing surfaces. **(5.2e)** ▪ Friction is a force that opposes motion. **(5.2d)** ▪ A complex machine uses a combination of interacting simple machines. **(5.2g)** ▪ Machines transfer mechanical energy from one object to another. **(5.2c)** ▪ Machines can change the direction or amount of force, or the distance or speed of force required to do work. **(5.2f)**	**Standard 6: Interconnectedness – Common Themes** **Key Idea 1:** Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions. **Key Idea 2:** Models are simplified representations of objects, structures, or systems used in the analysis, explanation, interpretation, or design. **Key Idea 3:** The grouping of magnitudes of sizes, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. **Key Idea 6:** In order to arrive at the best solution that meets the criteria within constraints, it is often necessary to make trade-offs. **Standard 7: Interdisciplinary Problem Solving** **Key Idea 1:** Describe and explain phenomena by designing and conducting investigations involving systematic observations, accurate measurements, and the identification and control of variables; by inquiring into relevant mathematical ideas; and by using mathematical and technological tools and procedures to assist in the investigation.	▪ Scientific relationships can be represented through the use of algebraic expressions and equations. ▪ Phenomena that can be observed at one scale may not be observable at another scale. **Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ▪ Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. ▪ Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. ▪ Models are limited in that they only represent certain aspects of the system under study. **Energy and Matter: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior. ▪ Matter is conserved because atoms are conserved in physical and chemical processes. ▪ Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. ▪ Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). ▪ The transfer of energy can be tracked as energy flows through a designed or natural system.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RHST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific works and phrases as they are used in a specific scientific or technical context relevant to Grades 6–8 text and topics.

RHST.6–8.9: Compare and contrast the information gained from experiments, simulations, video or multimedia sources with that gained from reading a text on the same topic.

WHST.6–8.6: Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.

WHST.6–8.7: Conduct short research projects to answer a question (including a self-generated question) drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Mathematics

6.RP.A.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, "*The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes.*"

6.RP.A.2: Understand the concept of a unit rate a/b associated with a ratio a:b with b≠0, and use rate language in the context of a ratio relationship. For example, "*This recipe has a ratio of 3 cups of flour to 4 cups of sugar, so there is 3/4 cup of flour for each cup of sugar." "We paid $75 for 15 hamburgers, which is a rate of $5 per hamburger.*"

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline C—Energy—Learners begin to grasp formal concepts related to energy by focusing on energy transfer and transformations. They are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.

Strand 2.4: Environment and Society

- Guideline A—Human/environment interactions—Learners understand that people depend on, change, and are affected by the environment.
- Guideline B—Places—Learners understand that places differ in their physical and human characteristics.
- Guideline C—Resources—Learners understand the basic concepts of resource and resource distribution.
- Guideline D—Technology—Learners understand that technology is an integral part of human existence and culture.
- Guideline E—Environmental issues—Learners are familiar with some local environmental issues and understand that people in other places experience environmental issues as well.

Grade 6 | Unit 2 Weather and the Atmosphere

RECOMMENDED TIME: NOVEMBER – FEBRUARY (12 WEEKS)

Unit Overview:

The unit studies physical properties of matter, energy transformations, as well as how energy is released or absorbed as light and as heat. This will provide a context for how weather conditions are produced in the atmosphere, and how weather events affect life in specific regions. Students may build tools to investigate weather in their local area, gathering and analyzing patterns and trends to describe weather conditions, make informed predictions, and explain hazardous weather conditions.

Essential Questions:

What causes weather conditions?

How do matter and energy interact to produce weather patterns?

Why do different locations have different weather conditions?

What short-term/long-term solutions can we propose that will help reduce pollution?

Key Ideas:

PS. Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

PS. Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

PS. Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

LE. Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from New York State Performance Indicators (PS. 2.1a,c,d,j; 2.2i-r; 3.1a, c-f, g, h; 3.2a; 4.1a, c,d; 4.2a - d; 4.4a, b; 4.5a, b) (LE.7.2d)

- The substances have characteristics properties. Some of these properties include color, odor, phase at room temperature, density, solubility, heat and electrical conductivity, hardness, and boiling and freezing points. **(3.1a)**
- Density can be described as the amount of matter that is in a given amount of space. If two objects have equal volume, but one has more mass, the one with more mass is denser. **(3.1h)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Cause and effect relationships may be used to predict phenomena in natural or designed systems.
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

continued

NYS SCIENCE STANDARDS http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf	MST STANDARDS http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf	NGSS CROSS-CUTTING CONCEPTS http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
- The motion of particles helps to explain the phases (states) of matter as well as changes from one phase to another. The phase in which matter exists depends on the attractive forces among its particles. **(3.1c)** - Gases have neither a determined shape nor definite volume. Gases assume the shape and volume of a closed container. **(3.1d)** - A liquid has definite volume, but takes the shape of a container. **(3.1e)** - A solid has definite shape and volume. Particles resist a change in position. **(3.1f)** - During a physical change a substance keeps its chemical composition and properties. Examples of physical changes include freezing, melting, condensation, boiling, evaporation, tearing, and crushing. **(3.2a)** - During a phase change, heat energy is absorbed or released. Energy is absorbed when a solid changes to a liquid and when a liquid changes to a gas. Energy is released when a gas changes to a liquid and when a liquid changes to a solid. **(4.2c)** - Most substances expand when heated and contract when cooled. Water is an exception, expanding when changing to ice. **(4.2d)** - Energy cannot be created or destroyed, but only changed from one form into another. **(4.5a)** - Energy can change from one form to another, although in the process some energy is always converted into heat. Some systems transform energy with less loss of heat than others. **(4.5b)** 🍃 - The Sun is the major source of energy for Earth. Other sources of energy include nuclear and geothermal energy. **(4.1a)**	**Key Idea 4:** Equilibrium is a state of stability due either to a lack of change (static equilibrium), or a balance between opposing forces (dynamic equilibrium). **Key Idea 5:** Identifying patterns of change is necessary for making predictions about future behavior and conditions. **Standard 7: Interdisciplinary Problem Solving** **Key Idea 1:** The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve probl3ems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.	**Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. - Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. - Small changes in one part of a system might cause large changes in another part. - Stability might be disturbed either by sudden events or gradual changes that accumulate over time. - Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- Different forms of energy include heat, light, electrical, mechanical, sound, nuclear and chemical. Energy is transformed in many ways. **(4.1d)**
- Most activities in everyday life involve one form of energy being transformed into another. For example, the chemical energy in gasoline is transformed into mechanical energy in an automobile engine. Energy, in the form of heat, is almost always one the product of energy transformations. **(4.1c)**
- Different forms of electromagnetic energy have different wavelengths. Some examples of electromagnetic energy are microwaves, infrared light. Visible light. Ultraviolet light, X-rays, and gamma rays. **(4.4a)**
- Light passes through some materials, sometimes refracting in the process. Materials absorb and reflect light, and may transmit light. To see an object, light from that object, emitted by or reflected from it, must enter the eye. **(4.4b)**
- Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both have reached the same temperature. **(4.2a)**
- Heat can be transferred through matter by the collisions of atoms and/or molecules (conduction) or through space (radiation). In liquid or gas, currents will facilitate the transfer of heat (convection). **(4.2b)**
- Nearly all the atmosphere is confined to a thin shell surrounding the Earth. The atmosphere is a mixture of gases, including nitrogen, oxygen, with small amounts of water vapor, carbon dioxide, and other trace gases. The atmosphere is stratified into layers, each having distinct properties. Nearly all weather occurs in the lowest layer of the atmosphere. **(2.1a)**
- The rock at Earth's surface forms a nearly continuous shell around Earth called the lithosphere. **(2.1c)**
- The majority of the lithosphere is covered by a relatively thin layer of water called the hydrosphere. **(2.1d)**
- Water circulates through the atmosphere, lithosphere, and hydrosphere in what is known as the water cycle. **(2.1j)**
- The uneven heating of Earth's surface is the cause of weather. **(2.2k)**
- Weather describes the conditions of the atmosphere at a given location for a short period of time. **(2.2i)**
- Air masses form when air remains nearly stationary over a large section of Earth's surface and takes on the conditions of temperature and humidity from that location. Weather conditions at a location are determined primarily by temperature, humidity, and pressure of air masses over that location. **(2.2l)**
- Most local weather condition changes are caused by movement of air masses. **(2.2m)**
- The movement of air masses is determined by prevailing winds and upper air currents. **(2.2n)**
- Fronts are boundaries between air masses. Precipitation is likely to occur at these boundaries. **(2.2o)**
- High-pressure systems generally bring fair weather. Low-pressure systems usually bring cloudy, unstable conditions. The general movement of highs and lows is from west to east across the United States. **(2.2p)**
- Hazardous weather conditions include thunderstorms, tornadoes, hurricanes, ice storms, and blizzards. Humans can prepare for and respond to these conditions if given sufficient warning. **(2.2q)**
- Substances enter the atmosphere naturally and from human activity. Some of these substances include dust from volcanic eruptions and greenhouse gases such as carbon dioxide, methane, and water vapor. These substances can affect weather, climate and living things. **(2.2r)**
- Since the Industrial Revolution, human activities have resulted in major pollution of air, water, and soil. Pollution has cumulative ecological effects such as acid rain, global warming, or ozone depletion. The survival of living things on our planet depends on the conservation and protection of Earth's resources. **(LE. 7.2d)**

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RHST.6–8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

RHST.6–8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

RHST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in specific scientific or technical context relevant to Grades 6–8 texts and topics.

RHST.6–8.5: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

WHST.6–8.4: Produce a clear and coherent writing in which the development, organization, and style are appropriate to task, purpose and audience.

WHST.6–8.6.8: Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Mathematics

6.SP.B.5: Summarize numerical data sets in relation to their context, such as by:

6.SP.B.5.A: Reporting the number of observations.

6.SP.B.5.B: Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

6.SP.B.5.C: Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

6.SP.B.5.D: Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline A—Processes that shape the Earth—Learners have a basic understanding of most of the physical processes that shape the Earth. They are able to explore the origin of differences in physical patterns.
- Guideline D—Global connections—Learners become familiar with ways in which the world's environmental, social, economic, cultural, and political systems are linked.
- Guideline E—Change and conflict—Learners understand that human social systems change over time and that conflicts sometimes arise over differing and changing viewpoints about the environment.

Grade 6 | Unit 3 Diversity of Life

RECOMMENDED TIME: FEBRUARY – APRIL (8 WEEKS)

Unit Overview:

Diversity of life is seen through the study of cells. Prokaryotic and eukaryotic cells, and animal and plant cells, are observed to describe their structure and to explain how these cells make different organisms. Students will understand how cells are the primary source for biodiversity, and will learn to classify organisms according to similarities and differences at the cellular and organism level, as well as using internal and external structures in living things. Students will also study how different organisms have different energy needs to live. They will understand that energy flows through ecosystems in one direction, usually from the Sun, through producers to consumers and then decomposers, in which its balance is the result of interactions between living and nonliving things. Students will be able to construct models of biomes and/or ecosystems they investigate and that will visually represent their explanation about how energy is used and transformed by different organisms in an ecosystem. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:

How does the transfer of matter and energy through biological communities support the diversity of living things?

Key Ideas:

LE. Key Idea 1: Living things are both similar to and different from each other and from nonliving things.

LE. Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

LE. Key Idea 6: Plants and animals depend on each other and their physical environment.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from New York State Performance Indicators (1.1a - h; 5.1c, d, e; 5.2a-e; 6.1a-c; 6.2a-c)

- Living things are composed of cells. Cells provide structure and carry on major functions to sustain life. Cells are usually microscopic in size. **(1.1a)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effectiveness.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

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NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
▪ The way in which cells function is similar in all living things. Cells grow and divide, producing more cells. Cells take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs. **(1.1b)** ▪ Most cells have cell membranes, genetic material, and cytoplasm. Some cells have a cell wall and/or chloroplasts. Many cells have a nucleus. **(1.1c)** ▪ Some organisms are single cells; others, including humans, are multicellular. **(1.1d)** ▪ Cells are organized for more effective functioning in multicellular organisms. Levels of organization for structure and function of a multicellular organism include cells, tissues, organs, and organ systems. **(1.1e)** ▪ Many plants have roots, stems, leaves, and reproductive structures. These organized groups of tissues are responsible for a plant's life activities. **(1.1f)** ▪ Multicellular animals often have similar organs and specialized systems for carrying major life activities. **(1.1g)** ▪ Living things are classified by shared characteristics on the cellular and organism level. In classifying organisms, biologists consider details of internal and external structures. Biological classification systems are arranged from general (kingdom) to specific (species). **(1.1h)** ▪ All organisms require energy to survive. The amount of energy needed and the method for obtaining this energy vary among cells. Some cells use oxygen to release the energy stored in food. **(5.1c)** ▪ The methods for obtaining nutrients vary among organisms. Producers, such as green plants. Use light energy to make their food. Consumers. Such as animals, take in energy-rich foods. **(5.1d)** *continued*	**Standard 6: Interconnectedness: Common Themes** **Key Idea 1:** Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions. **Key Idea 2:** Models are simplified representations of objects, structures, or systems used in the analysis, explanation, interpretation, or design. **Key Idea 4:** Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium). **Standard 7: Interdisciplinary Problem Solving** **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among common themes of mathematics, science and technology; and presenting results.	▪ Models are limited in that they only represent certain aspects of the system under study. **Energy and Matter: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior. ▪ Matter is conserved because atoms are conserved in physical and chemical processes. ▪ Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. ▪ Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). ▪ The transfer of energy can be tracked as energy flows through a designed or natural system.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- Herbivores obtain energy from plants. Carnivores obtain energy from animals. Omnivores obtain energy from both plants and animals. Decomposers, such as bacteria and fungi, obtain energy by consuming wastes and/or dead organisms. **(5.1e)**
- Food provides molecules that serve as fuel and building material for all organisms. All living things, including plants, must release energy from their food, using it to carry on their life processes. **(5.2a)** 🍃
- Foods contain a variety of substances, which include carbohydrates, fats, vitamins, proteins, minerals, and water. Each substance is vital to the survival of the organism. **(5.2b)**
- Metabolism is the sum of all chemical reactions in an organism. Metabolism can be influenced by hormones, exercise, diet, and aging. **(5.2c)**
- Energy in foods is measured in Calories. The total caloric value of each type of food varies. The number of Calories a person requires varies from person to person. **(5.2d)**
- In order to maintain a balanced state, all organisms have a minimum daily intake of each type of nutrient based on species, size, activity, etc. An imbalance in any of the nutrients might results in weight gain, weight loss, or a diseased state. **(5.2e)**
- Energy flows through ecosystems in one direction, usually from the Sun, through producers to consumers and then to decomposers. This process may be visualized with food chains or energy pyramids. **(6.1a)** 🍃
- Food webs identify feeding relationships among producers, consumers, and decomposers in an ecosystem. **(6.1b)**
- Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment. **(6.1c)** 🍃
- Photosynthesis is carried on by green plants and other organisms containing chlorophyll. In this process, the Sun's energy is converted into and stored as chemical energy in the form of a sugar. The quantity of sugar molecules increases in green plants during photosynthesis in the presence of sunlight. **(6.2a)**
- The major source of atmospheric oxygen is photosynthesis. Carbon dioxide is removed from the atmosphere and oxygen is released during photosynthesis. **(6.2b)** 🍃
- Green plants are the producers of food which is used directly or indirectly by consumers. **(6.2c)**

COMMON CORE STATE STANDARDS

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http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.6–8.1: Cite specific textual evidence to support analysis of science and technical texts.

RST.6–8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in specific scientific or technical context relevant to Grades 6–8 texts and topics.

RST.6–8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

WHST.6–8.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.6–8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Mathematics

6RP.A.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, “*The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every two wings there was one beak.*”

6RP.A.3: Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

ENVIRONMENTAL GUIDELINES FOR LEARNING

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Strand 2: Knowledge Of Environmental Processes And Systems

Strand 2.1: The Earth as a Physical System

- Guideline B—Changes in matter—Learners understand the properties of the substances that make up objects or materials found in the environment.
- Guideline C—Energy—Learners begin to grasp formal concepts related to energy by focusing on energy transfer and transformations. They are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.

Strand 2.2: The Living Environment

- Guideline C—Systems and connections—Learners understand major kinds of interactions among organisms or populations of organisms.
- Guideline D—Flow of matter and energy—Learners understand how energy and matter flow among the abiotic and biotic components of the environment.

Grade 6 | Unit 4 Interdependence

RECOMMENDED TIME: APRIL – JUNE (8 WEEKS)

Unit Overview:

This unit continues the study of ecosystems and how living things interact with all physical factors in their living environment. Each ecosystem has its own set of environmental conditions that determine biodiversity. Climatic factors, competition among populations, and changes in environmental conditions help maintain a balance in the growth of certain populations. All living things have adaptations that enable them to live within ecosystems under specific environmental conditions. Abrupt changes in the environment will make living things change, adapt, or migrate, in order to preserve life. During and after this unit of study, students should be able to investigate how changes in physical factors affect the survival of living things in particular biomes and/or ecosystems.
[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]

Essential Questions:

In what ways are living and nonliving things dependent upon each other?

What factors affect the interdependence of living and nonliving things?

Key Ideas:

PS. Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

LE. Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

LE. Key Idea 6: Plants and animals depend on each other and their physical environment.

LE. Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from New York State Performance Indicators (LE.1.1h; 1.2e, 3.2a; 5.1a, b, f, g; 7.1a-e; 7.2a-d) (PS. 1.1i; 2.1b, 2.2i,r)

- Climate is the characteristic weather that prevails from season to season and year to year. **(PS 2.2i)**
- The tilt of Earth's axis of rotation and the revolution of Earth around the Sun cause seasons on Earth. The length of daylight varies depending on latitude and longitude. **(PS 1.1i)**
- As altitude increases, air pressure decreases. **(PS 2.1b)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effectiveness and ethical use.

Key Idea 3: Information technology can have positive and negative impacts on society, depending upon how it is used.

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NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.
- Models are limited in that they only represent certain aspects of the system under study.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- Substances enter the atmosphere naturally and from human activity. Some of these substances include dust from volcanic eruptions and greenhouse gases such as carbon dioxide, methane and water vapor. These substances can affect weather, climate, and living things. **(PS 2.2r)** 🍃
- Living things are classified by shared characteristics on the cellular and organism level. In classifying organisms, biologists consider details of internal and external structures. Biological classification systems are arranged from general (kingdom) to specific (species). **(1.1h)**
- A population consists of all individuals of a species that are found together at a given place and time. Populations living in one place form a community. The community and the physical factors with which it interacts compose an ecosystem. **(7.1a)**
- Given adequate resources and no disease or predators, populations (including humans) increase. Lack of resources, habitat destruction, and other factors such as predation and climate limit the growth of certain populations in the ecosystem. **(7.1b)** 🍃
- In all environments, organisms interact with one another in many ways. Relationships among organisms may be competitive, harmful, or beneficial. Some species have adapted to be dependent upon each other with the result that neither could survive without the other. **(7.1c)**
- Some microorganisms are essential to the survival of other living things. **(7.1d)**
- In all environments, organisms with similar needs may compete with one another for resources. **(3.2a)**
- In ecosystems, balance is the result of interactions between community members and their environment. **(7.2a)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- Matter is conserved because atoms are conserved in physical and chemical processes.
- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).
- The transfer of energy can be tracked as energy flows through a designed or natural system.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- The environment may be altered through the activities of organisms. Alterations are sometimes abrupt. Some species may replace others over time, resulting in long-term gradual changes (ecological succession). **(7.2b)** 🍃
- Overpopulation by any species impacts the environment due to increase use of resources. Human activities can bring about environmental degradation through resource acquisition, urban growth, land-use decisions, waste disposal, etc. **(7.2c)** 🍃
- Since the Industrial Revolution, human activities have resulted in major pollution of air, water and soil. Pollution has cumulative ecological effects such as acid rain, global warming, or ozone depletion. The survival of living things on our planet depends on the conservation and protection of Earth's resources. **(7.2d)** 🍃
- The environment may contain dangerous levels of substances (pollutants) that are harmful to organisms. Therefore, the good health of environments and individuals requires the monitoring of soil, air, and water, and taking steps to keep them safe. **(7.1e)** 🍃
- The excretory system functions in the disposal of dissolved waste molecules, the elimination of liquid and gaseous wastes, and the removal of excess heat energy. **(1.2e)**
- Animals and plants have a great variety of body plans and internal structures that contribute to their ability to maintain a balanced condition. **(5.1a)**
- An organism's overall body plan and its environment determine the way that the organism carries out the life processes. **(5.1b)**
- Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required for survival. Regulation includes a variety of nervous and hormonal feedback systems. **(5.1f)**
- The survival of an organism depends on its ability to sense and respond to its external environment. **(5.1g)** 🍃

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- The observed function of natural and designed systems may change with scale.
- Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
- Scientific relationships can be represented through the use of algebraic expressions and equations.
- Phenomena that can be observed at one scale may not be observable at another scale.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 6–8 texts and topics.

RST.6–8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

RST.6–8.7: Integrate quantitative or technical information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

WHST.6–8.7: Conduct a short research project to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6–8.8: Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism.

WHST.6–8.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

6.SP.A.2: Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

6.SP.B.4: Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline C—Energy—While they may have little understanding of formal concepts associated with energy, learners are familiar with the basic behavior of some different forms of energy.

Strand 2.2: The Living Environment

- Guideline A—Organisms, populations, and communities—Learners understand that biotic communities are made up of plants and animals that are adapted to l ive in particular environments.
- Guideline C—Systems and connections—Learners understand major kinds of interactions among organisms or populations of organisms.
- Guideline D—Flow of matter and energy—Learners understand how energy and matter flow among the abiotic and biotic components of the environment.

Grade 7 | Unit 1
Geology

RECOMMENDED TIME: SEPTEMBER – OCTOBER (7 WEEKS)

Unit Overview:

This unit studies the surface of planet Earth, as well as the natural phenomena that causes the surface to change over time. Students will be able to make different types of models representing the lithosphere that will best help them describe changes in the surface of the planet. In addition, they will analyze data from earthquakes and volcanoes, and charts that represent the long history of Earth, drawing conclusions about how these forces of nature provoke short-term, long-term, and permanent changes to the surface of the planet.

Essential Questions:

How do different natural phenomena change the surface of the Earth over time?

To what extent do natural occurrences affect the Earth over time?

How do scientists use data and technology to make predictions about natural phenomena?

How have environmental conditions influenced the changes in the Earth's surface?

Key Ideas:

PS. Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective.

PS. Key Idea 2: Many phenomena that we observe on Earth involve interactions among components of air, water, and land.

LE. Key Idea 3: Individual organisms and species change over time.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (PS 1.1f, j; 2.1a, c, e-j; 2.2a–h; 3.1i; 4.2b) (LE. 3.2b, c)

- The shape of the Earth, the other planets and stars are nearly spherical. **(1.1j)**
- The latitude/longitude coordinate system and our system of time are based on celestial observations. **(1.1f)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve process and communicate information as tools to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effectiveness and ethical use.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- Nearly all the atmosphere is confined to a thin shell surrounding Earth. The atmosphere is a mixture of gases, including nitrogen and oxygen with small amounts of water vapor, carbon dioxide, and other trace gases. The atmosphere is stratified into layers, each having distinct properties. Nearly all weather occurs in the lowest layer of the atmosphere. **(2.1a)**
- The majority of the lithosphere is covered by a relatively thin layer of water called the hydrosphere. **(2.1d)**
- The rock at Earth's surface forms a nearly continuous shell around Earth called the lithosphere. **(2.1c)**
- Rocks are composed of minerals. Only a few rock-forming minerals make up most of the rocks of Earth. Minerals are identified on the basis of physical properties such as streak, hardness, and reaction to acid. **(2.1e)**
- Rocks are classified according to their method of formation. The three classes of rocks are sedimentary, metamorphic and igneous. Most rocks show characteristics that provide clues to their formation conditions. **(2.2g)**
- The rock cycle model shows how types of rock material may be transformed from one type of rock to another. **(2.2h)**
- Fossils are usually found in sedimentary rocks. Fossils are great evidence that a great variety of species existed in the past. **(LE. 2.1f)**
- Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to permit its survival. Extinction of species is common. Fossils are evidence that a great variety of species existed in the past. **(3.2b)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Standard 7: Interdisciplinary Problem Solving – Connections

Key Idea 1: Describe and explain phenomena by designing and conducting investigations involving systematic observations, accurate measurements, and the identification and control of variables; by inquiring into relevant mathematical ideas; and by using mathematical and technological tools and procedures to assist in the investigation.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.
- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- Many thousands of layers of sedimentary rock provide evidence for the long history of Earth and for the long history of changing life forms whose remains are found in the rocks. Recently deposited rock layers are more likely to contain fossils resembling existing species. **(LE. 3.2c)**
- The dynamic processes that wear away Earth's surface include weathering and erosion. **(2.1g)** 🍃
- Erosion is the transport of sediment. Gravity is the driving force behind erosion. Gravity can act directly or through agents such as moving water, wind, and glaciers. **(2.1i)**
- The process of weathering breaks down rocks to form sediment. Soil consists of sediment, organic material, water and air. **(2.1h)** 🍃
- Heat can be transferred through matter by the collisions of atoms and/or molecules (conduction) or through space (radiation). In a liquid or gas, currents will facilitate the transfer of heat (convection). **(4.2b)**
- Buoyancy is determined by comparative densities. **(3.1i)**
- The interior of the Earth is hot. Heat flow and movement of material within the Earth cause sections of Earth crust to move. This may result in earthquakes, volcanic activity, and the creation of mountain and oceanic basins. **(2.2a)**
- Analysis of earthquake wave data leads to the conclusion that there are layers within the Earth. These layers have distinctive properties. **(2.2b)**
- Folded, tilted, faulted and displaced rock layers suggest past crustal movement. **(2.2c)**
- Continents fitting together like puzzle parts and fossil correlations provided initial evidence that continents were once together. **(2.2d)**
- The Theory of Plate Tectonics explains how the "solid" lithosphere consists of a series of plates that "float" on the partially molten section of the mantle. Convection cells within the mantle may be the driving force for the movement of the plates. **(2.2e)**
- Plates may collide, move apart, or slide past one another. Most volcanic activity and mountain building occur at the boundaries of these plates, often resulting in earthquakes. **(2.2f)**

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.
- Models are limited in that they only represent certain aspects of the system under study.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific odds and phrases as they are used in a specific scientific or technical context relevant to Grades 6–8 texts and topics.

RST.6–8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

RST.6–8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

WHST.6–8.4: Produce a clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.6–8.5: With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.

WHST.6–8.8: Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Mathematics

7RP.2: Recognize and represent proportional relationships between two quantities.
b) Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline A—Processes that shape the Earth—Learners have a basic understanding of most of the physical processes that shape the Earth. They are able to explore the origin of differences in physical patterns.
- Guideline B—Changes in matter—Learners understand the properties of the substances that make up objects or materials found in the environment.
- Guideline C—Energy—Learners begin to grasp formal concepts related to energy by focusing on energy transfer and transformations. They are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.

Grade 7 | Unit 2 Energy and Matter

RECOMMENDED TIME: NOVEMBER – JANUARY (12 WEEKS)

Unit Overview:

Students will describe matter by its physical properties and will explain its behavior by using its chemical properties. Knowledge of physical and chemical changes will enable students to understand how matter and energy interact in many dynamic ways. As students understand these interactions between matter and energy, they should also be able to investigate and explain how pollutants enter and remain in the environment, and its consequences for living and nonliving things. Students should be able to propose ideas and ways to preserve a healthy living environment with a minimum amount of pollutants. *[Refer to Appendix A for Conservation Day]*

Essential Questions:

What makes matter?

How does matter behave?

How does matter relate to energy?

How is energy transferred from one material to another?

How is energy transformed?

What materials are best to conserve and efficiently use energy?

To what extent do chemicals affect living and nonliving things?

Key Ideas:

PS. Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

PS. Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

LE. Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from New York State Performance Indicators (PS. 3.1a-h; 3.2a-e; 3.3a-d, f, g; 4.1d; 4.2e; 4.3a; 4.4a-d, f, g; 4.5 a, b; LE. 7.1e)

- Energy cannot be created or destroyed, but only changed from one form into another. **(4.5a)**
- Different forms of energy include heat, light, electrical, mechanical, sound, nuclear, and chemical. Energy is transformed in many ways. **(4.1d)**

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness

Key Idea 1: Systems Thinking: through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- Matter is conserved because atoms are conserved in physical and chemical processes.
- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- Energy can change from one form to another, although in the process some energy is always converted to heat. Some systems transform energy with less loss of heat than others. **(4.5b)**
- Different forms of electromagnetic energy have different wavelengths. Some examples of electromagnetic energy are microwaves, infrared light, visible light, ultraviolet light, X-rays, and gamma rays. **(4.4a)**
- Light passes through some materials, sometimes refracting in the process. Materials absorb and reflect light, and may transmit light. To see and object, light from that object, emitted by or reflected from it, must enter the eye. **(4.4b)**
- Vibrations in materials set up wave-like disturbances that spread away from the source. Sound waves are an example. Vibrational waves move at different speeds in different materials. Sound cannot travel in a vacuum. **(4.4c)**
- Substances have characteristic properties. Some of these properties include color, odor, phase at room temperature, density, solubility, heat and electrical conductivity, hardness, and boiling and freezing points. **(3.1a)**
- The motion of particles helps explain the phases (states) of matter as well as changes from one phase to another. The phase in which matter exists depends on the attractive forces among particles. **(3.1c)**
- Gases have neither a determined shape nor a definitive volume. Gases assume the shape and volume of a closed container. **(3.1d)**
- A liquid has definitive volume, but takes the shape of a container. **(3.1e)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: Connections: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- The transfer of energy can be tracked as energy flows through a designed or natural system.

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Cause and effect relationships may be used to predict phenomena in natural or designed systems.
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Small changes in one part of a system might cause large changes in another part.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- A solid has definite shape and volume. Particles resist a change in position. **(3.1f)**
- Density can be described as the amount of matter that is in a given amount of space. If two objects have equal volume, but one has more mass, the one with more mass is denser. **(3.1h)**
- Without direct contact, a magnet attracts certain materials and either attracts or repels other magnets. The attractive force of a magnet is greatest at its poles. **(4.4g)**
- Without touching them, material that has been electrically charged attracts uncharged material, and may either attract or repel other charged material. **(4.4f)**
- Electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy. **(4.4d)**
- During a physical change a substance keeps its chemical composition and properties. Examples of physical changes include freezing, melting, condensation, boiling, evaporation, tearing, and crushing. **(3.2a)**
- Mixtures are physical combinations of materials and can be separated by physical means. **(3.2b)**
- Characteristic properties can be used to identify different materials, and separate a mixture of substances into its components. For example, iron can be removed from a mixture by means of a magnet. An insoluble substance can be separated from a soluble substance by such processes as filtration, settling, and evaporation. **(3.1g)**
- Solubility can be affected by the nature of the solute and solvent, temperature, and pressure. The rate of solution can be affected by the size of the particles, stirring, temperature, and the amount of solute already dissolved. **(3.1b)**
- Temperature affects the solubility of some substances in water. **(4.2e)**
- All matter is made up atoms. Atoms are far too small to see with a light microscope. **(3.3a)**
- Atoms and molecules are perpetually in motion. The greater the temperature, the greater the motion. **(3.3b)**
- Atoms may join together in well-defined molecules or may be arranged in regular geometric patterns. **(3.3c)**
- The atoms of any one element are different from the atoms of other elements. **(3.3e)**
- There are more than 100 elements. Elements combine in a multitude of ways to produce compounds that account for all living and nonliving substances. Few elements are found in their pure form. **(3.3f)**
- The periodic table is one useful model for classifying elements. The periodic table can be used to predict properties of elements (metals, nonmetals, noble gases). **(3.3g)**
- Substances are often placed in categories if they react in similar ways. Examples include metals, nonmetals and noble gases. **(3.2d)**
- During a chemical change, substances react in characteristic ways to form new substances with different physical and chemical properties. Examples of chemical changes include burning wood, cooking of an egg, rusting of iron, and souring of milk. **(3.2c)**
- Interactions among atoms and/or molecules result in chemical reactions. **(3.3d)**
- In chemical reactions, energy is transferred into or out of a system. Light, electricity, or mechanical motion may be involved in such transfers in addition to heat. **(4.3a)**
- The Law of Conservation of Mass states that during an ordinary chemical reaction matter cannot be created or destroyed. In chemical reactions, the total mass of the reactants equals the total mass of the products. **(3.2e)**
- The environment may contain dangerous levels of substances (pollutants) that are harmful to organisms. Therefore, the good health of environments and individuals requires the monitoring of soil, air, and water, and taking steps to keep them safe. **(LE 7.1e)**

NGSS CROSS-CUTTING CONCEPTS

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- Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy, matter, and information flows within systems.
- Models are limited in that they only represent certain aspects of the system under study.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.6–8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of a text distinct form prior knowledge or opinions.

RST.6–8.3: Follow precisely a multistep procedure when carrying out experiment, taking measurements, or performing technical tasks.

RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a scientific or technical context relevant to Grades 6–8 texts and topics.

RST.6–8.9: Compare and contrast the information gained form experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

WHST.6–8.2: Write informative/explanatory texts, including the narration of scientific procedures/experiments, or technical processes.

Mathematics

7NS.1: Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. a) Describe situations in which opposite quantities combine to make 0. For example, a hydrogen atom has zero charge because its two constituents are oppositely charged.

7NS.3: Solve real-world and mathematical problems involving the four operations with rational numbers.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline A—Processes that shape the Earth—Learners have a basic understanding of most of the physical processes that shape the Earth. They are able to explore the origin of differences in physical patterns.
- Guideline B—Changes in matter—Learners understand the properties of the substances that make up objects or materials found in the environment.
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Grade | **Unit**

7 | 3 Dynamic Equilibrium: The Human Animal

RECOMMENDED TIME: FEBRUARY – MARCH (8 WEEKS)

Unit Overview:

Through this unit, students will understand the cell, the function of organs, and how these work together as a system. Students must be able to explain and conclude that, despite changes, the connection of organ systems, and the maintenance of a proper metabolism, will provide a dynamic equilibrium for life.

Essential Questions:

How do cells function to sustain human life?

How do human body systems function to maintain homeostasis?

How can environmental conditions affect human survival?

Key Ideas:

LE. Key Idea 1: Living things are both similar to and different from each other and from nonliving things.

LE. Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (LE. 1.1a-e, g, h; 1.2a-h; 5.1a-g; 5.2a-c, e, f,)

- Living things are composed of cells. Cells provide structure and carry on major functions to sustain life. Cells are usually microscopic in size. **(1.1a)**
- Some organisms are single cells; others, including humans, are multicellular. **(1.1d)**
- Most cells have cell membranes, genetic material, and cytoplasm. Some cells have a cell wall and/or chloroplasts. Many cells have a nucleus. **(1.1c)**
- The way in which cells function is similar in all living things. Cells grow and divide, producing more cells. Cells take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs. **(1.1b)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effectiveness and ethical use.

Standard 6: Interconnectedness

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in the analysis, explanation, interpretation, or design.

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NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.
- Models are limited in that they only represent certain aspects of the system under study.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
▪ Cells are organized for more effective functioning in multicellular organisms. Levels of organization for structure and function of a multicellular organism include cells, tissues, organs, and organ systems. **(1.1e)** ▪ Each system is composed of organs and tissues which perform specific functions and interact with each other. **(1.2a)** ▪ Tissues, organs and organ systems help provide all cells with nutrients, oxygen, and waste removal. **(1.2b)** ▪ Multicellular animals often have similar organs and specialized systems for carrying out major life activities. **(1.1g)** ▪ Animals have a great variety of body plans and internal structures that contribute to their ability to maintain a balanced condition. **(5.1a)** ▪ An organism's overall body plan and its environment determine the way that the organism carries out the life processes. **(5.1b)** ▪ All organisms require energy to survive. The amount of energy needed and the method for obtaining this energy vary among cells. Some cells use oxygen to release the energy stored in food. **(5.1c)** ▪ The methods for obtaining nutrients vary among organisms. Producers, such as green plants, use light energy to make their own food. Consumers, such as animals, take in energy-rich foods. **(5.1d)** 🍃 ▪ Herbivores obtain energy from plants. Carnivores obtain energy from animals. Omnivores obtain energy from both plants and animals. Decomposers, such as bacteria and fungi, obtain energy by consuming wastes and/or dead organisms. **(5.1e)** *continued*	**Key Idea 4:** Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium). **Standard 7: Interdisciplinary Problem Solving** **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits, gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.	**Energy and Matter: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior. ▪ Matter is conserved because atoms are conserved in physical and chemical processes. ▪ Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. ▪ Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). ▪ The transfer of energy can be tracked as energy flows through a designed or natural system. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ▪ Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. ▪ Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- Food provides molecules that serve as fuel and building material for all organisms. All living things, including plants, must release energy from their food, using it to carry on their life process. **(5.2a)**
- Foods contain a variety of substances, which include carbohydrates, fats, vitamins, proteins, minerals, and water. Each substance is vital to the survival of the organism. **(5.2b)**
- Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required for survival. Regulation includes a variety of nervous and hormonal feedback systems. **(5.1f)**
- The nervous and endocrine systems interact to control and coordinate the body's responses to changes in the environment, and to regulate growth, development, and reproduction. Hormones are chemicals produced by the endocrine system; hormones regulate many body functions. **(1.2h)**
- The respiratory system supplies oxygen and removes carbon dioxide (gas exchange). **(1.2d)**
- The circulatory system moves substances to and from cells, where they are needed or produced, responding to changing demands. **(1.2f)**
- The excretory system functions in the disposal of dissolved waste molecules, the elimination of liquid and gaseous wastes, and the removal of excess heat energy. **(1.2e)**
- The digestive system consists of organs that are responsible for the mechanical and chemical breakdown of food. The breakdown process results in molecules that can be absorbed and transported to cells. **(1.2c)**
- Metabolism is the sum of all chemical reactions in an organism. Metabolism can be influenced by hormones, exercise, diet and aging. **(5.2c)**
- Energy in foods is measured in Calories. The total caloric value of each type of food varies. The number of Calories a person requires varies from person to person. **(5.2d)**
- In order to maintain a balanced state, all organisms have a minimum daily intake of each type of nutrient based on species, size, age, sex, activity, etc. An imbalance in any of the nutrients might result in weight gain, weight loss, or diseased state. **(5.2e)**
- The survival of an organism depends on its ability to sense and respond to its external environment. **(5.1g)**
- Locomotion, necessary to escape danger, obtains food and shelter, and reproduce, is accomplished by the interaction of the skeletal and muscular systems, and coordinated by the nervous system. **(1.2g)**

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.6–8.1: Cite specific textual evidence to support analysis of science and technical texts.

RST.6–8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 6–8 texts and topics.

WHST.6–8.4: Produce a clear and coherent writing in which the development, organization, and style are appropriate to task, purpose and audience.

WHST.6–8.5: With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.2: The Living Environment

- Guideline A—Organisms, populations, and communities—Learners understand that biotic communities are made up of plants and animals that are adapted to live in particular environments.
- Guideline B—Heredity and evolution—Learners have a basic understanding of the importance of genetic heritage.
- Guideline C—Systems and connections—Learners understand major kinds of interactions among organisms or populations of organisms.
- Guideline D—Flow of matter and energy—Learners understand how energy and matter flow among the abiotic and biotic components of the environment.

Grade | **Unit**

7 | 4 Dynamic Equilibrium: Other Organisms

RECOMMENDED TIME: MAY – JUNE (8 WEEKS)

Unit Overview:

This unit continues building understanding of the structure and function of other organisms, by exploring body systems of plants and other animals, including single-celled organisms and invertebrates. Students will compare and contrast how these organisms regulate and maintain homeostasis, drawing conclusions about their physical needs and how they maintain a dynamic equilibrium. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Questions:

How do differences in structures or functions promote biodiversity among living things?

How do living things function to maintain a dynamic equilibrium?

How do organisms adapt to their environment in order to survive?

How do differences in structure and/or function influence biodiversity among living things?

Key Ideas:

LE. Key Idea 1: Living things are both similar to and different from each other and from nonliving things.

LE. Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (LE. 1.1 b-g; 1.2 a-f; 4.3c, d; 5.1 a-g; 5.2a-c, e; 6.2a-c)

- Some organisms are single cells; others, including humans, are multicellular. **(1.1d)**
- Most cells have cell membranes, genetic material, and cytoplasm. Some cells have a cell wall and/or chloroplasts. Many cells have a nucleus. **(1.1c)**
- Cells are organized in a more effective way in multicellular organisms. Levels of organization for structure and function of a multicellular organism include cells, tissues, organs and organ systems. **(1.1e)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.
- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- Multicellular animals often have similar organs and specialized systems for carrying out major life activities. **(1.1g)**
- Each system is composed of organs and tissues which perform specific functions and interact with each other, e.g., digestion, gas exchange, excretion, circulation, locomotion, control, coordination, reproduction, and protection from disease. **(1.2a)**
- Tissues, organs, and organ systems help to provide all cells with nutrients, oxygen, and waste removal. **(1.2b)**
- All organisms require energy to survive. The amount of energy needed and the method for obtaining energy vary among cells. Some cells use oxygen to release the energy stored in food. **(5.1c)**
- The methods for obtaining nutrients vary among organisms. Producers, such as green plants, use light energy to make their food. Consumers, such as animals, take in energy-rich foods. **(5.1d)**
- Herbivores obtain energy from plants. Carnivores obtain energy from animals. Omnivores obtain energy from both plants and animals. Decomposers, such as bacteria and fungi, obtain energy by consuming wastes and/or dead organisms. **(5.1e)**
- The digestive system consists of organs that are responsible for the mechanical and chemical breakdown of food. The breakdown process results in molecules that can be absorbed and transported to cells. **(1.2c)**
- Food provides molecules that serve as fuel and building material for all organisms. All living things, including plants, must release energy from their food, using it to carry on their life processes. **(5.2a)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- The observed function of natural and designed systems may change with scale.
- Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
- Scientific relationships can be represented through the use of algebraic expressions and equations.
- Phenomena that can be observed at one scale may not be observable at another scale.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.
- Models are limited in that they only represent certain aspects of the system under study.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- Foods contain a variety of substances, which include carbohydrates, fats, vitamins, proteins, minerals, and water. Each substance is vital to the survival of the organism. **(5.2b)** 🍃
- In order to maintain a balanced state, all organisms have a minimum daily intake of each type of nutrient based on species, size, age, sex, activity, etc. An imbalance in any of the nutrients might result in weight gain, weight loss, or a disease state. **(5.2e)** 🍃
- During respiration, cells use oxygen to release the energy stored in food. The respiratory system supplies oxygen and removes carbon dioxide (gas exchange). **(1.2d)**
- The excretory system functions in the disposal of dissolved waste molecules. The elimination of liquid and gaseous wastes, and the removal of excess heat energy. **(1.2e)**
- The circulatory system moves substances to and from cells, where they are needed or produced, responding to changing demands. **(1.2f)**
- Regulation of an organism’s internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required for survival. Regulation includes a variety of nervous and hormonal feedback systems. **(5.1f)** 🍃
- The survival of an organism depends on its ability to sense and respond to its external environment. **(5.1g)** 🍃
- Many plants have roots, stems, leaves, and reproductive structures. These organized groups of tissues are responsible for a plant’s life activities. **(1.1f)**
- Plants have a great variety of body plans and internal structures that contribute to their ability to maintain a balanced condition. **(5.1a)**
- Photosynthesis is carried out by green plants and other organisms containing chlorophyll. In this process, the Sun’s energy is converted into and stored as chemical energy in the form of sugar. The quantity of sugar molecules increases in green plants during photosynthesis in the presence of sunlight. **(6.2a)** 🍃
- The major source of atmospheric oxygen is photosynthesis. Carbon dioxide is removed from the atmosphere and oxygen is released during photosynthesis. **(6.2b)**
- Green plants are the producers of food which is used directly or indirectly by consumers. **(6.2c)** 🍃
- Metabolism is the sum of all chemical reactions in an organism. Regulation of an organism’s internal environment and changing physical activities to keep conditions within the range required for survival. **(5.2c)**
- An organism’s body plan and its environment determine the way that the organism carries out the life processes. **(5.1b)** 🍃
- Various body structures and functions change as an organism goes through its life cycle. **(4.3c)**
- Patterns of development vary among animals. In some species the young resemble the adult, while in others they do not. Some insects and amphibians undergo metamorphosis as they mature. **(4.3d)**

COMMON CORE STATE STANDARDS http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf	ENVIRONMENTAL GUIDELINES FOR LEARNING http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf
ELA/Literacy **RST.6–8.3:** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. **RST.6–8.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 6–8 texts and topics. **WHST.6–8.4:** Produce a clear and coherent writing in which the development, organization, and style are appropriate to task, purpose and audience. **WHST.6–8.5:** With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. **Mathematics** **7.SP.A.1:** Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences. **7.SP.A.2:** Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.	**Strand 2: Knowledge of Environmental Processes and Systems** **Strand 2.2: The Living Environment** ▪ Guideline A—Organisms, populations, and communities—Learners understand that biotic communities are made up of plants and animals that are adapted to live in particular environments. ▪ Guideline B—Heredity and evolution—Learners have a basic understanding of the importance of genetic heritage. ▪ Guideline C—Systems and connections—Learners understand major kinds of interactions among organisms or populations of organisms. ▪ Guideline D—Flow of matter and energy—Learners understand how energy and matter flow among the abiotic and biotic components of the environment.

Grade **Unit**

8 1 Reproduction, Heredity, and Evolution

RECOMMENDED TIME: SEPTEMBER – NOVEMBER (10 WEEKS)

Unit Overview:

During this unit, students will compare and contrast the processes of asexual and sexual reproduction. They will also learn the structure of reproductive organs as well as the function of the organs on the reproductive, endocrine and immune systems. This knowledge leads to the study of how environmental and physical factors impact and contribute to biodiversity. At the end of the unit, students should be able to describe the genetic product of cell division and its implications in terms of diversity of life. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Questions:

How does life on Earth continue and adapt in response to environmental changes?

How may advances in genetic engineering affect the variations of species?

How do environmental conditions affect the survival of individual organisms?

Key Ideas:

LE. Key Idea 1: Living things are both similar and different from each other and from nonliving things.

LE. Key Idea 2: Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

LE. Key Idea 4: The continuity of life is sustained through reproduction and development.

LE. Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from New York State Performance Indicators (LE 1.2i, h, j 2.1a-e; 2.2a-c; 3.1a-c; 3.2a–d; 4.1a-d, 4.2b; 4.3a-f; 4.4 –d; 7.2d)

- In asexual reproduction, all genes come from a single parent. Asexually produced offspring are genetically identical to the parent. **(2.1d)**
- Some organisms reproduce asexually. Other organisms reproduce sexually. Some organisms can reproduce both asexually and sexually. **(4.1a)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 4: Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.
- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

continued

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■ There are many methods of asexual reproduction, including division of a cell into two cells, or separation of part of an animal or plant from the parent, resulting in the growth of another individual. **(4.1b)** ■ In sexual reproduction typically half of the genes come from each parent. Sexually produced offspring and not identical of either parent. **(2.1e)** ■ Methods of sexual reproduction depend upon the species. All methods involve the merging of sex cells to begin the development of a new individual. In many species, including plants and humans, eggs and sperm are produced. **(4.1c)** ■ The male sex cell is the sperm. The female sex cell is the egg. The fertilization of an egg by a sperm results in a fertilized egg. **(4.2a)** ■ In sexual reproduction, sperm and egg each carry one-half of the genetic information for the new individual. Therefore, the fertilized egg contains genetic information from each parent. **(4.2b)** ■ Fertilization and/or development in organisms may be internal or external. **(4.1d)** ■ Multicellular organisms exhibit complex changes in development, which begin after fertilization. The fertilized egg undergoes numerous cellular divisions that will results in a multicellular organism, with each cell having identical genetic information. **(4.3a)** ■ In humans, the fertilized egg grows into tissue which develops into organs and organ systems before birth. **(4.3b)** ■ Various body structures and functions change as an organism goes through its life cycle. **(4.3c)** *continued*	**Standard 7: Interdisciplinary Problem Solving** **Key Idea 1:** The knowledge of science, mathematics, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.	**Patterns:** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. ■ Macroscopic patterns are related to the nature of microscopic and atomic-level structure. ■ Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems. ■ Patterns can be used to identify cause and effect relationships. ■ Graphs, charts, and images can be used to identify patterns in data. **Cause and Effect: Mechanism and Prediction:** Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. ■ Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. ■ Cause and effect relationships may be used to predict phenomena in natural or designed systems. ■ Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

- Patterns of development vary among animals. In some species the young resemble the adult, while in others they do not. Some insects and amphibians undergo metamorphosis as they mature. **(4.3d)**
- Patterns of development vary among plants. In seed-bearing plants, seeds contain stored food for early development. Their later development into adulthood is characterized by varying patterns of growth from species to species. **(4.3e)**
- As an individual organism ages, various body structures and functions change. **(4.3f)**
- In multicellular organisms, cell division is responsible for growth, maintenance, and repair. In some one-celled organisms, cell division is a method of sexual reproduction. **(4.4a)**
- In one type of cell division, chromosomes are duplicated and then separated into two identical and complete sets to be passed to each of the two resulting cells. In this type of cell division, the hereditary information is identical in all the cells that result. **(4.4b)**
- Another type of cell division accounts for the production of egg and sperm cells in sexually reproducing organisms. The eggs and sperm resulting from this type of cell division contain one-half of the hereditary information. **(4.4c)**
- Cancers are a result of abnormal cell division. **(4.4d)**
- Hereditary information is contained in genes. Genes are composed of DNA that makes up the chromosomes of cells. **(2.1a)**
- Each gene carries a single unit of information. A single inherited trait of an individual can be determined by one pair or by many pairs of genes. A human cell contains thousands of different genes. **(2.1b)**
- Each human cell contains a copy of all genes needed to produce a human being. **(2.1c)**
- In all organisms, genetic traits are passed on from generation to generation. **(2.2a)**
- Some genes are dominant and some are recessive. Some traits are inherited by mechanism other than dominance and recessiveness. **(2.2b)**
- The probability of traits being expressed can be determined using models of genetic inheritance. Some models of predictions are pedigree and Punnett squares. **(2.2c)**
- The processes of sexual reproduction and mutation have been given rise to a variety of traits within species. **(3.1a)**
- The male and female reproductive systems are responsible for producing sex cells necessary for the production of offspring. **(1.2i)**
- The nervous and endocrine systems interact to control and coordinate the body's responses to changes in the environment, and to regulate growth, development, and reproduction. Hormones are chemicals produced by the endocrine system; hormones regulate many body functions. **(1.2h)**
- Disease breaks down the structures or functions of an organism. Some diseases are the result of failures of the system. Other diseases are the result of damage by infection from other organisms (germ theory). Specialized cells protect the body from infectious disease. The chemicals they produce identify and destroy microbes that enter the body. **(1.2j)** 🍃
- Changes in environmental conditions can affect the survival of individual organisms with a particular trait. Small differences between parents and offspring can accumulate in successive generations so that descendants are very different from their ancestors. Individual organisms with certain traits are more likely to survive and have offspring than individuals without those traits. **(3.1b)** 🍃
- Human activities such as selective breeding and advances in genetic engineering may affect the variations of species. **(3.1c)**
- In all environments, organisms with similar needs may compete with one another for resources. **(3.2a)** 🍃
- Extinction of species occurs when the environment changes and the adaptive characteristics of a species are insufficient to permit its survival. Extinction of species is common. Fossils are evidence that a great variety of species existed in the past. **(3.2b)** 🍃
- Many thousands of layers of sedimentary rock provide evidence for the long history of Earth and for the long history of changing lifeforms whose remains are found in the rocks. Recently deposited rock layers are more likely to contain fossils resembling existing species. **(3.2c)**
- Although the time needed for changes in a species is usually great, some species of insects and bacteria have undergone significant change in just a few years. **(3.2d)**
- Since the Industrial Revolution, human activities have resulted in major pollution of air, water, and soil. Pollution has cumulative ecological effects such as acid rain, global warming, or ozone depletion. The survival of living things on our planet depends on the conservation and protection of Earth's resources. **(7.2d)** 🍃

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.6–8.1: Cite specific textual evidence to support analysis of science and technical texts.

RST.6–8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 6–8 texts and topics.

WHST.6–8.4: Produce a clear and coherent writing in which the development, organization, and style are appropriate to task, purpose and audience.

WHST.6–8.5: With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.

WHST.6–8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6–8.8: Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.2: The Living Environment

- Guideline A—Organisms, populations, and communities—Learners understand that biotic communities are made up of plants and animals that are adapted to live in particular environments.
- Guideline B—Heredity and evolution—Learners have a basic understanding of the importance of genetic heritage.
- Guideline C—Systems and connections—Learners understand major kinds of interactions among organisms or populations of organisms.

Mathematics

6.RP.A.3: Use ratio and rate reasoning to solve real-world and mathematical problems.

7.SP.C.5: Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring. Larger numbers indicate greater likelihood. A probability near 0 indicates an unlikely event, a probability around 1/2 indicates an event that is neither unlikely nor likely, and a probability near 1 indicates a likely event.

7.SP.C.6: Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability. For example, when rolling a number cube 600 times, predict that a 3 or 6 would be rolled roughly 200 times, but probably not exactly 200 times.

8.EE.3: Use numbers expressed in the form of a single digit times an integer power of ten to estimate very large or very small quantities, and to express how many times as much as one is than the other. For example, estimate the population of the United States as the 3x10^8 and the population of the world as 7x10^9, and determine that the world population is more than 20 times larger.

Grade 8 | Unit 2

Forces and Motion on Earth

RECOMMENDED TIME: NOVEMBER – DECEMBER (5 WEEKS)

Unit Overview:

During this unit, students will learn the effects of different types of forces on the motion of objects, through the study of the Newton's laws of motion. Students should be able to explain how changes in motion, perspective, and reference of objects, depend on different variables such as mass, direction of motion, and frame of reference.

Essential Questions:

How do we apply the laws of motion to explain the movement of objects on Earth?

To what extent do variables affect motion and force?

How can people use the laws of motion to ensure safety?

Key Ideas:

PS. Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective.

PS. Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from New York State Performance Indicators (PS. 5.1a-e; 5.2b)

- The motion of an object is always judged with respect to some other object or point. The idea of absolute motion or rest is misleading. **(5.1a)**
- The motion of an object can be described by its position, direction of motion, and speed. **(5.1b)**
- An object's motion is the result of the combined effect of all forces acting on the object. A moving object that is not subjected to a force will continue to move at a constant speed in a straight line. An object at rest will remain at rest. **(5.1c)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve process and communicate information as tools to enhance learning.

Standard 6: Interconnectedness – Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all system and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanations, interpretation, or design.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Cause and effect relationships may be used to predict phenomena in natural or designed systems.
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
■ Force is directly related to an object's mass and acceleration. The greater the force, the greater the change in motion. **(5.1d)** ■ For every action there is an equal and opposite reaction. **(5.1e)** ■ Electric currents and magnets can exert a force on each other. **(5.2b)**	**Key Idea 5:** Identifying patterns of change is necessary for making predictions about future behavior and conditions. 5.1—Use simple linear equations to represent how a parameter changes with time. **Standard 7: Interdisciplinary – Problem Solving** **Key Idea 1:** The knowledge of science, mathematics, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.	**Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ■ Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. ■ Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy, matter, and information flows within systems. ■ Models are limited in that they only represent certain aspects of the system under study. **Patterns:** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. ■ Macroscopic patterns are related to the nature of microscopic and atomic-level structure. ■ Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems. ■ Patterns can be used to identify cause and effect relationships. ■ Graphs, charts, and images can be used to identify patterns in data.

COMMON CORE STATE STANDARDS http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf	ENVIRONMENTAL GUIDELINES FOR LEARNING http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf
ELA/Literacy **RST.6–8.1:** Cite specific textual evidence to support analysis of science and technical texts. **RST.6–8.3:** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. **RST.6–8.4:** Determine the meaning of symbols, key terms and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 6–8 texts and topics. **RST.6–8.9:** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading text on the same topic. **WHST.6–8.1:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.6–8.8:** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format of citation. **WHST.6–8.9:** Draw evidence from informational texts to support analysis, reflection, and research. **Mathematics** **8.EE.B.5:** Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed.	**Strand 2: Knowledge of Environmental Processes and Systems** **Strand 2.1: The Earth as a Physical System** ▪ Guideline A—Processes that shape the Earth—Learners have a basic understanding of most of the physical processes that shape the Earth. They are able to explore the origin of differences in physical patterns. ▪ Guideline C—Energy—Learners begin to grasp formal concepts related to energy by focusing on energy transfer and transformations. They are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.

Grade 8 | Unit 3

The Sun, Earth, and Moon System

RECOMMENDED TIME: JANUARY – MARCH (10 WEEKS)

Unit Overview:

This unit studies the interactions and relationship between the Sun, Earth, and Moon. Predictable motions of the Moon and Earth cause natural phenomena that impact life on Earth. Students will understand better the concepts of patterns, cause and effect, and energy, when they construct models that will best represent their explanation about how forces maintain the Sun, Earth, and Moon system in a predictable motion, and how this predictable motion is the effect of many natural events, such as tides and eclipses.

Essential Questions:

What roles do forces play in the patterns and stability of the solar system?

How do the forces in the solar system affect phenomena on Earth?

How do scientists use technology to understand the behavior of the Sun, Earth, and Moon system?

How did scientists and philosophers use the environment around them to explain and formulate ideas about our time system?

Key Ideas:

PS. Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective.

PS. Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from New York State Performance Indicators (1.1d,e,h, i, g; 1.1a-c; 5.1a, b, c; 5.2a)

- Most objects in the solar system have regular and predictable motion. These motions explain such phenomena as a day, a year, and phases of the Moon; eclipses, tides, meteor showers, and comets. **(1.1e)**

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effectiveness and ethical use.

Standard 6: Interconnectedness – Common Themes

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanations, interpretation, or design.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
- Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems.
- Patterns can be used to identify cause and effect relationships
- Graphs, charts, and images can be used to identify patterns in data.

continued

NYS SCIENCE STANDARDS

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- The apparent motions of the Sun, Moon, planets and stars across the sky can be explained by Earth's rotation and revolution. Earth's rotation causes the length of one day to be approximately 24 hours. This rotation also causes the Sun and Moon to appear to rise along the eastern horizon and to set along the western horizon. Earth's revolution around the Sun defines the length of the year as 365 and 1/4 days. **(1.1h)**
- The tilt of Earth's axis of rotation and the revolution of Earth around the Sun cause seasons on Earth. The length of daylight varies depending on latitude and season. **(1.1i)**
- Moons are seen by reflected light. Our Moon orbits earth, while Earth orbits the Sun. The Moon's phases as observed from Earth are the result of seeing different portions of the lighted area of the Moon's surface. The phases repeat in a cyclic pattern in about one month. **(1.1g)**
- Earth's Sun is an average-sized star. The Sun is more than a million times greater in volume than Earth. **(1.1a)**
- Other stars are like the Sun but are so far away that they look like points of light. Distances between stars are vast compared to distances within our solar system. **(1.1b)**
- The Sun and the planets that revolve around it are the major bodies in the solar system. Other members include comets, moons, and asteroids. Earth's orbit is nearly circular. **(1.1c)**
- Gravity is the force that keeps planets in orbit around the Sun and the Moon in orbit around the Sun. **(1.1d)**
- The latitude/longitude coordinate system and our system of time are based on celestial observations. **(1.1f)**

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MST STANDARDS

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Key Idea 3: The grouping of magnitudes and size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions. 5.1 – Use simple linear equations to represent how a parameter changes with time.

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge of science, mathematics, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

NGSS CROSS-CUTTING CONCEPTS

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Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Cause and effect relationships may be used to predict phenomena in natural or designed systems.
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- The observed function of natural and designed systems may change with scale.
- Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
- Scientific relationships can be represented through the use of algebraic expressions and equations.
- Phenomena that can be observed at one scale may not be observable at another scale.

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▪ The motion of an object is always judged with respect to some other object or point. The idea of absolute motion or rest is misleading. **(5.1a)** ▪ The motion of an object can be described by its position, direction of motion, and speed. **(5.1b)** ▪ An object's motion is the result of the combined effect of all forces acting on the object. A moving object that is not subjected to a force will continue to move at a constant speed in a straight line. An object at rest will remain at rest. **(5.1c)** ▪ Every object exerts gravitational force on every other object. Gravitational force depends on how much mass the objects have and how far apart they are. Gravity is on the forces acting on orbiting objects and projectiles. **(5.2a)**		**Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ▪ Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. ▪ Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. ▪ Models are limited in that they only represent certain aspects of the system under study.

COMMON CORE STATE STANDARDS

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ELA/Literacy

RST.6–8.1: Cite specific textual evidence to support analysis of science and technical texts.

RST.6–8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

RST.6–8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 6–8 texts and topics.

RST.6–8.5: Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.

RST.6–8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

RST.6–8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

WHST.6–8.1 (a-e): Write arguments focused on discipline-specific content.

WHST.6–8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6–8.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

8.EE.A.4: Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology.

ENVIRONMENTAL GUIDELINES FOR LEARNING

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Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline A—Processes that shape the Earth—Learners have a basic understanding of most of the physical processes that shape the Earth. They are able to explore the origin of differences in physical patterns.
- Guideline C—Energy—Learners begin to grasp formal concepts related to energy by focusing on energy transfer and transformations. They are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.

Grade 8 | Unit 4

Humans and the Environment: Needs and Tradeoffs

RECOMMENDED TIME: APRIL – JUNE (12 WEEKS)

Unit Overview:

This unit studies energy and materials needs, and how the use of resources of energy impacts the environment for living things. At the end of this unit, students should be able to discuss the impact of the use of energy resources and publish written sources about solutions to different environmental issues, and pose the use of alternative energy resources. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Questions:

How does human consumption of resources affect the environment and our health?

How do environmental changes and adaptive characteristics of a species affect survival?

How can energy resources affect the future planning for the continuity of life on Earth?

Key Ideas:

LE. Key Idea 3: Individual organisms change over time.

PS. Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

LE. Key Idea 6: Plants and animals depend on each other and their physical environment.

LE. Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Major Understandings:

Quoted from New York State Performance Indicators (LE.1.2j, 3.2a, b; 4.4d; 5.2a-d, f; 6.1c; 7.1e, 7.2b, c, d) (PS. 4.1a-e; 4.4d ,e; PS. 4.5a, b)

- In all environments, organisms with similar needs may compete with one another for resources. **(3.2a)**
- Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to permit its survival. Extinction of species is common. Fossils are evidence that a great variety of species existed in the past. **(3.2b)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effectiveness and ethical use.

Key Idea 3: Information technology can have positive and negative impacts on society, depending upon how it is used.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
- Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems.
- Patterns can be used to identify cause and effect relationships.
- Graphs, charts, and images can be used to identify patterns in data.

continued

NYS SCIENCE STANDARDS

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- The Sun is a major source of energy for Earth. Other sources of energy include nuclear and geothermal energy. **(4.1a)**
- Fossil fuels contain stored solar energy and are considered nonrenewable resources. They are a major resource of energy in the United States. Solar energy, wind, moving water, and biomass are some examples of renewable energy resources. **(4.1b)**
- Most activities in everyday life involve one form of energy being transformed into another. For example, the chemical energy in gasoline is transformed into mechanical energy in an automobile engine. Energy, in the form of heat, is almost always one of the products of energy transformation. **(PS. 4.1c)**
- Different forms of energy include heat, light, electrical, mechanical, sound, nuclear, and chemical. Energy is transformed in many ways. **(PS. 4.1d)**
- Energy can be considered to be either kinetic energy, which is energy of motion, or potential energy, which depends on relative position. **(4.1e)**
- Electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy. **(PS. 4.4d)**
- Electrical circuits provide a means of transferring electrical energy. **(PS. 4.4e)**
- Matter is transferred from one organism to another and between organisms and their physical environment. Water, nitrogen, carbon dioxide, and oxygen are examples of substances cycled between the living and nonliving environment. **(6.1c)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/intersci.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 4: Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Key Idea 6: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Standard 7: Interdisciplinary Problem Solving

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science and technology; and presenting results.

NGSS CROSS-CUTTING CONCEPTS

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Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

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- Cause and effect relationships may be used to predict phenomena in natural or designed systems.
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- Matter is conserved because atoms are conserved in physical and chemical processes.
- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

continued

NYS SCIENCE STANDARDS

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- The environment may contain dangerous levels of substances (pollutants) that are harmful to organisms. Therefore, the good health of environments and individuals requires the monitoring of soil, air, and water, and taking steps to keep them safe. **(7.1e)**
- The environment may be altered through the activities of organisms. Alterations are sometimes abrupt. Some species may replace other over time, resulting in long-term gradual changes (ecological succession). **(7.2b)**
- Overpopulation by any species impacts the environment due to the increased use of resources. Human activities can bring about environmental degradation through resource acquisition, urban growth, land-use decisions, waste disposal, etc. **(7.2c)**
- Since the Industrial Revolution, human activities have resulted in major pollution of air, water, and soil. Pollution has cumulative ecological effects such as acid rain, global warming, or ozone depletion. The survival of living things on our planet depends on the conservation and protection of Earth's resources. **(7.2d)**
- Energy cannot be created or destroyed, but only changed from one form into another. **(PS. 4.5a)**
- Energy can be changed from one form to another, although in the process some energy is always converted into heat. Some systems transform energy with less loss of heat than others. **(PS. 4.5b)**
- Food provides molecules that serve as fuel and building for all organisms. All living things, including plants, must release energy from their food, using it to carry on their life processes. **(5.2a)**
- Foods contain a variety of substances, which include carbohydrates, fats, vitamins, proteins, minerals, and water. Each substance is vital to the survival of the organism. **(5.2b)**
- Disease breaks down the structures or functions of an organism. Some diseases are the result of failures of the system. Other diseases are the result of damage by infection from other organisms (germ theory). Specialized cells protect the body form infectious disease. The chemicals they produce identify and destroy microbes that enter the body. **(1.2j)**
- Contraction of infectious disease, and personal behaviors such as use of toxic substances and some dietary habits, may interfere with one's dynamic equilibrium. During pregnancy these conditions may also affect the development of the child. Some effects of these conditions are immediate; others may not appear for many years. **(5.2f)**
- Cancers are a result of abnormal cell division. **(4.4d)**

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).
- The transfer of energy can be tracked as energy flows through a designed or natural system.

COMMON CORE STATE STANDARDS

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http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

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RST.6–8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

RST.6–8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 6–8 texts and topics.

RST.6–8.5: Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.

RST.6–8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

WHST.6–8.1 (a–e): Write arguments focused on discipline-specific content.

WHST.6–8.6: Use technology, including the Internet, to produce and publish writing and present the relationship between information and ideas clearly and efficiently.

WHST.6–8.7: Conduct short research projects to answer a question (including self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Mathematics

8.SP.A.4: Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies in a two-way table summarizing data on two categorical variables collected form the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables.

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Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline C—Energy—Learners begin to grasp formal concepts related to energy by focusing on energy transfer and transformations. They are able to make connections among phenomena such as light, heat, magnetism, electricity, and the motion of objects.

Strand 2.2—The Living Environment

- Guideline A—Organisms, populations, and communities—Learners understand that biotic communities are made up of plants and animals that are adapted to live in particular environments.
- Guideline C—Systems and connections—Learners understand major kinds of interactions among organisms or populations of organisms.
- Guideline D—Flow of matter and energy—Learners understand how energy and matter flow among the abiotic and biotic components of the environment.

Strand 2.3—Humans and Their Societies

- Guideline A—Individuals and groups—Learners understand that how individuals perceive the environment is influenced in part by individual traits and group membership or affiliation.
- Guideline D—Global connections—Learners become familiar with ways in which the world's environmental, social, economic, cultural, and political systems are linked.
- Guideline E—Change and conflict—Learners understand that human social systems change over time and that conflicts sometimes arise over differing and changing viewpoints about the environment.

Strand 2.4—Environment and Society

- Guideline A—Human/environment interactions—Learners understand that human-caused changes have consequences for the immediate environment as well as for other places and future times.
- Guideline B—Places—Learners begin to explore the meaning of places both close to home and around the world.

continued

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	■ Guideline C—Resources—Learners understand that uneven distribution of resources influences their use and perceived value. ■ Guideline D—Technology—Learners understand the human ability to shape and control the environment as a function of the capacities for creating knowledge and developing new technologies. ■ Guideline E—Environmental issues—Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that people in other places around the world experience environmental issues similar to the ones they are concerned about locally.

Grades 6-8 Cross-Cutting Concepts

Patterns: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.	▪ Macroscopic patterns are related to the nature of microscopic and atomic-level structure. ▪ Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems. ▪ Patterns can be used to identify cause and effect relationships. ▪ Graphs, charts, and images can be used to identify patterns in data.
Cause and Effect: Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which t hey are mediated, is a major activity of science and engineering.	▪ Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. ▪ Cause and effect relationships may be used to predict phenomena in natural or designed systems. ▪ Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.	▪ Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. ▪ The observed function of natural and designed systems may change with scale. ▪ Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. ▪ Scientific relationships can be represented through the use of algebraic expressions and equations. ▪ Phenomena that can be observed at one scale may not be observable at another scale.
Systems and System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.	▪ Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. ▪ Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. ▪ Models are limited in that they only represent certain aspects of the system under study.
Energy and Matter: Flows, Cycles, and Conservation: Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.	▪ Matter is conserved because atoms are conserved in physical and chemical processes. ▪ Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. ▪ Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). ▪ The transfer of energy can be tracked as energy flows through a designed or natural system.

Grades 6-8 Cross-Cutting Concepts

Structure and Function: The way an object is shaped or structured determines many of its properties and functions.	▪ Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. ▪ Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.	▪ Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. ▪ Small changes in one part of a system might cause large changes in another part. ▪ Stability might be disturbed either by sudden events or gradual changes that accumulate over time. ▪ Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.

Developed by NSTA using information from Appendix G of the Next Generation Science Standards © 2011, 2012, 2013 Achieve, Inc.

Adapted from: National Research Council (2011). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academy Press. Chapter 4: Crosscutting Concepts.

Grades

6-8 Engineering Design

Asking Questions and Defining Problems	Developing and Using Models	Planning and Carrying Out an Investigation	Analyzing and Interpreting Data	Using Mathematics and Computational Thinking	Constructing Explanations and Defining Solutions	Engaging in Argument From Evidence	Obtaining, Evaluating, and Communicating Information
Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. Identify and/or clarify evidence and/or the premise(s) of an argument. Determine relationships between independent and dependent variables and relationships in models. Clarify and/or refine a model, an explanation, or an engineering problem: • that requires sufficient and appropriate empirical evidence to answer • that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources When appropriate, frame a hypothesis based on observations and	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Evaluate limitations of a model for a proposed object or tool. Develop or modify a model—based on evidence—to match what happens if a variable or component of a system is changed. Use and/or develop a model of simple systems with uncertain and less predictable factors. Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. Develop and/or use a model to predict and/or describe phenomena. Develop a model to describe unobservable mechanisms. Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems,	Planning and carrying out investigations in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. Plan an investigation individually and collaboratively, and in the design and identify independent and dependent variables and controls • what tools are needed to do the gathering • how measurements will be recorded • how many data are needed to support a claim Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. Evaluate the accuracy of various methods for collecting data. Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions	Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. Distinguish between causal and correlational relationships in data. Analyze and interpret data to provide evidence for phenomena. Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy	Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. Use mathematical representations to describe and/or support scientific conclusions and design solutions. Create algorithms (a series of ordered steps) to solve a problem. Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems. Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. Construct an explanation using models or representations. Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) 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. Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.	Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Make an oral or written argument that supports or refutes the advertised performance of a device,	Obtaining, evaluating and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods. Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts.
continued	*continued*	*continued*	*continued*		*continued*	*continued*	*continued*

Grades

6-8 Engineering Design

Asking Questions and Defining Problems	Developing and Using Models	Planning and Carrying Out an Investigation	Analyzing and Interpreting Data	Using Mathematics and Computational Thinking	Constructing Explanations and Defining Solutions	Engaging in Argument From Evidence	Obtaining, Evaluating, and Communicating Information
scientific principles that challenge the premise(s) of an argument or the interpretation of a data set. Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	including those representing inputs and outputs, and those at unobservable scales.	under a range of conditions. Collect data about the performance of a proposed object, tool, process, or system under a range of conditions.	precision and accuracy of data with better technological tools and methods (e.g., multiple trials). Analyze and interpret data to determine similarities and differences in findings. Analyze data to define an optimal operational range for a proposed object, tool, process, or system that best meets criteria for success.		Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process, or system. Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. Optimize performance of a design by prioritizing criteria, making trade-offs, testing, revising, and retesting.	process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	Communicate scientific and/or technical information (e.g., about a proposed object, tool, process, system) in writing and/or through oral presentations.

LE

Living Environment

LE | Unit 1 Scientific Inquiry

RECOMMENDED TIME: 10 DAYS

Unit Overview:

Science relies on logic and creativity. Science is both a body of knowledge and a way of knowing—an intellectual and social process that applies human intelligence to explaining how the world works. Scientific explanations are developed using both observations (evidence) and what people already know about the world (scientific knowledge). All scientific explanations are tentative and subject to change. Good science involves questioning, observing and inferring, experimenting, finding evidence, collecting and organizing data, drawing valid conclusions, and undergoing peer review. Understanding the scientific view of the natural world is an essential part of personal, societal, and ethical decision making. Scientific literacy involves internalizing the scientific critical attitude so that it can be applied in everyday life, particularly in relation to health, commercial, and technological claims. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:

How do scientists pose questions, seek answers, and develop solutions?

Key Ideas:

This unit is focused on all of the key ideas in Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering designs, as appropriate, to pose questions, seek answers, and develop solutions.

Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing and creative process.

Key Idea 2: Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Key Idea 3: The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into natural phenomena.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (Standard 1:1.1a-c, 1.2a, b, 1.3a, b, 1.4a, 2.1, 2.2a, 2.3a-c, 2.4, 3.1, 3.2, 3.3, 3.4a-c, 3.5a, b)

- Scientific explanations are built by combining evidence that can be observed with what people already know about the world. **(1.1a)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Standard 2: Information Systems

Students will access, generate, process, and transfer information using appropriate technologies.

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf** **http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
■ Learning about the historical development of scientific concepts or about individuals who have contributed to scientific knowledge provides a better understanding of scientific inquiry and the relationship between science and society. **(1.1b)** 🍃 ■ Science provides knowledge, but values are also essential to making effective and ethical decisions about the application of scientific knowledge. **(1.1c)** 🍃 ■ Interpretation of data leads to development of additional hypotheses, the formulation of generalizations, or explanations of natural phenomena. **(3.1a)** 🍃 ■ Apply statistical analysis techniques when appropriate to test if chance alone explains the results. **(3.2)** 🍃 ■ Assess correspondence between the predicted result contained in the hypothesis and actual result, and reach a conclusion as to whether the explanation on which the prediction was based is supported. **(3.3)** 🍃 ■ Inquiry involves asking questions and locating, interpreting, and processing information from a variety of sources. **(1.2a)** 🍃 ■ Inquiry involves making judgments about the reliability of the source and relevance of information. **(1.2b)** 🍃 ■ Scientific explanations are accepted when they are consistent with experimental and observational evidence and when they lead to accurate predictions. **(1.3a)** 🍃 ■ All scientific explanations are tentative and subject to change or improvement. Each new bit of evidence can create more questions than it answers. This leads to increasingly better understanding of how things work in the living world. **(1.3b)** 🍃 ■ Devise ways of making observations to test proposed explanations. **(2.1)** 🍃	**Standard 6: Interconnectedness: Common Themes** **Key Idea 3:** The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. **Key Idea 4:** Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium). **Key Idea 5:** Identifying patterns of change is necessary for making predictions about future behaviors and conditions.	■ Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. ■ Mathematical representations are needed to identify some patterns. ■ Empirical evidence is needed to identify patterns. **Cause and Effect: Mechanism and Prediction:** Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. ■ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Scale, Proportion, and Quantity:** In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. ■ 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). **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. ■ Much of science deals with constructing explanations of how things change and how they remain stable.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

- Development of a research plan involves researching background information and understanding the major concepts in the area being investigated. Recommendations for methodologies, use of technologies, proper equipment, and safety precautions should also be included. **(2.2a)**
- Hypotheses are predictions based upon both research and observation. **(2.3a)**
- Hypotheses are widely used in science for determining what data to collect and as a guide for interpreting the data. **(2.3b)**
- Development of a research plan for testing a hypothesis requires planning to avoid bias (e.g., repeated trials, large sample size, and objective data-collection techniques). **(2.3c)**
- Carry out a research plan for testing explanations, including selecting and developing techniques, acquiring and building apparatus, and recording observations as necessary. **(2.4)**
- Hypotheses are valuable, even if they turn out not to be true, because they may lead to further investigation. **(3.4a)**
- Claims should be questioned if the data are based on samples that are very small, biased, or inadequately controlled or if the conclusions are based on the faulty, incomplete, or misleading use of numbers. **(3.4b)**
- Claims should be questioned if fact and opinion are intermingled, if adequate evidence is not cited, or if the conclusions do not follow logically from the evidence given. **(3.4c)**
- One assumption of science is that other individuals could arrive at the same explanation if they had access to similar evidence. Scientists make the results of their investigations public; they should describe the investigations in ways that enable others to repeat the investigations. **(3.5a)**
- Scientists use peer review to evaluate the results of scientific investigations and the explanations proposed by other scientists. They analyze the experimental procedures, examine the evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations. **(3.5b)**
- Well-accepted theories are ones that are supported by different kinds of scientific investigations often involving the contributions of individuals from different disciplines. **(1.4a)**
- Also see Laboratory Checklist in NYSED Core Curriculum Appendix A.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

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.

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.

RST.9-10.9: Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

WHST.9-10.1: Write arguments focused on discipline-specific content.

WHST.9-10.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)

WHST.9-10.5: 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.

WHST.9-10.6: Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

WHST.9-10.7: 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.

continued

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 1: Questioning, Analysis, and Interpretation Skills

- Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose.
- Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena.
- Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data.
- Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources.
- Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes.
- Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena.
- Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

WHST.9-10.9 : Draw evidence from informational texts to support analysis, reflection, and research.

WHST.9-10.10: Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

Mathematics

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

LE Unit 2 Ecology

RECOMMENDED TIME: 25 DAYS

Unit Overview:

The fundamental concept of ecology is that living organisms interact with and are dependent on their environment and each other. These interactions result in a flow of energy and a cycling of materials that are essential for life. Competition can occur between members of different species for an ecological niche. Competition can also occur within species. Competition may be for abiotic resources, such as space, water, air, and shelter, and for biotic resources, such as food and mates. Students should be familiar with the concept of food chains and webs. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:

Why doesn't any one type of living thing take over the world?

Key Ideas:

Key Idea 1: Living things are both similar to and different from each other and from nonliving things.

Key Idea 6: Plants and animals depend on each other and their physical environment.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (1.1a-f, 6.1a-g, 6.2a, b, 6.3a-c)

- In all environments, organisms compete for vital resources. The linked and changing interactions of populations and the environment compose the total ecosystem. **(1.1c)**
- The interdependence of organisms in an established ecosystem often results in approximate stability over hundreds and thousands of years. For example, as one population increases, it is held in check by one or more environmental factors or another species. **(1.1d)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

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NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Empirical evidence is needed to identify patterns.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

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NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf** **http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
▪ Relationships between organisms may be negative, neutral, or positive. Some organisms may interact with one another in several ways. They may be in a producer/consumer, predator/prey, or parasite/host relationship; or one organism may cause disease in, scavenge, or decompose another. **(6.1g)** ▪ As a result of evolutionary processes, there is a diversity of organisms and roles in ecosystems. This diversity of species increases the chance that at least some will survive in the face of large environmental changes. Biodiversity increases the stability of the ecosystem. **(6.2a)** ▪ Biodiversity also ensures the availability of a rich variety of genetic material that may lead to future agricultural or medical discoveries with significant value to humankind. As diversity is lost, potential sources of these materials may be lost with it. **(6.2b)** ▪ The interrelationships and interdependencies of organisms affect the development of stable ecosystems. **(6.3a)** ▪ Populations can be categorized by the function they serve. Food webs identify the relationships among producers, consumers, and decomposers carrying out either autotropic or heterotropic nutrition. **(1.1a)** ▪ An ecosystem is shaped by the nonliving environment as well as its interacting species. The world contains a wide diversity of physical conditions, which creates a variety of environments. **(1.1b)** ▪ The interdependence of organisms in an established ecosystem often results in approximate stability over hundreds and thousands of years. For example, as one population increases, it is held in check by one or more environmental factors or another species. **(1.1d)**	**Key Idea 4:** Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium). **Key Idea 5:** Identifying patterns of change is necessary for making predictions about future behavior and conditions.	▪ 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). **Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ▪ 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. **Energy and Matter: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior. ▪ Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems. ▪ 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. ▪ Energy drives the cycling of matter within and between systems. **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. ▪ Much of science deals with constructing explanations of how things change and how they remain stable.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

- Ecosystems, like many other complex systems, tend to show cyclic changes around a state of approximate equilibrium. **(1.1e)**
- Every population is linked, directly or indirectly, with many others in an ecosystem. Disruptions in the numbers and types of species and environmental changes can upset ecosystem stability. **(1.1f)**
- Energy flows through ecosystems in one direction, typically from the Sun, through photosynthetic organisms including green plants and algae, to herbivores to carnivores and decomposers. **(6.1a)**
- The atoms and molecules on the Earth cycle among the living and nonliving components of the biosphere. For example, carbon dioxide and water molecules used in photosynthesis to form energy-rich organic compounds are returned to the environment when the energy in these compounds is eventually released by cells. Continual input of energy from sunlight keeps the process going. This concept may be illustrated with an energy pyramid. **(6.1b)**
- The chemical elements, such as carbon, hydrogen, nitrogen, and oxygen, that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat. **(6.1c)**
- The number of organisms any habitat can support (carrying capacity) is limited by the available energy, water, oxygen, and minerals, and by the ability of ecosystems to recycle the residue of dead organisms through the activities of bacteria and fungi. **(6.1d)**
- In any particular environment, the growth and survival of organisms depend on the physical conditions including light intensity, temperature range, mineral availability, soil/rock type, and relative acidity (pH). **(6.1e)**
- Living organisms have the capacity to produce populations of unlimited size, but environments and resources are finite. This has profound effects on the interactions among organisms. **(6.1f)**
- Through ecological succession, all ecosystems progress through a sequence of changes during which one ecological community modifies the environment, making it more suitable for another community. These long-term gradual changes result in the community reaching a point of stability that can last for hundreds or thousands of years. **(6.3b)**
- A stable ecosystem can be altered, either rapidly or slowly, through the activities of organisms (including humans), or through climatic changes or natural disasters. The altered ecosystem can usually recover through gradual changes back to a point of long-term stability. **(6.3c)**

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.9-10.2: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

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.

WHST.9-10.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.5: 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.

WHST.9-10.6: Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

WHST.9-10.7: 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.

WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 1: Questioning, Analysis, and Interpretation Skills

- Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose.
- Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena.
- Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.2: The Living Environment

- Guideline A—Organisms, populations, and communities—Learners understand basic population dynamics and the importance of diversity in living systems.
- Guideline C—Systems and connections—Learners understand the living environment to be comprised of interrelated, dynamic systems.
- Guideline D—Flow of matter and energy—Learners are able to account for environmental characteristics based on their knowledge of how matter and energy interact in living systems.

LE | Unit 3 Organization and Patterns in Life

RECOMMENDED TIME: 20 DAYS

Unit Overview:

Living things are similar in that they rely on many of the same processes to stay alive, yet are different in the ways that these processes are carried out. Nonliving things lack certain features of living organisms, such as the ability to maintain a cellular organization, carry out metabolic processes while maintaining internal stability (homeostasis), and pass on hereditary information through reproduction. Different organisms have different regulatory mechanisms that function to maintain the level of organization necessary for life. Life is dependent upon availability of an energy source and raw materials that are used in the basic enzyme-controlled biochemical processes of living organisms. These biochemical processes occur within a narrow range of conditions. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:

How is a single-celled organism similar to and different from a human?

Key Ideas:

Key Idea 1: Living things are both similar to and different from each other and from nonliving things.

Key Idea 4: The continuity of life is sustained through reproduction and development.

Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (1.2a, c, e-j, 1.3a, 4.1a, b, 5.1a-g)

- Important levels of organization for structure and function include organelles, cells, tissues, organs, organ systems, and whole organisms. **(1.2a)**
- The organs and systems of the body help to provide all the cells with their basic needs. The cells of the body are of different kinds and are grouped in ways that enhance how they function together. **(1.2e)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.
- Changes in systems may have various causes that may not have equal effects.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

- Each cell is covered by a membrane that performs a number of important functions for the cell. These include: separation from its outside environment, controlling which molecules enter and leave the cell, and recognition of chemical signals. The processes of diffusion and active transport are important in the movement of materials in and out of cells. **(1.2g)**
- Inside the cell a variety of specialized structures, formed from many different molecules, carry out the transport of materials (cytoplasm), extraction of energy from nutrients (mitochondria), protein building (ribosomes), waste disposal (cell membrane), storage (vacuole), and information storage (nucleus). **(1.2i)**
- The components of the human body, from organ systems to cell organelles, interact to maintain a balanced internal environment. To successfully accomplish this, organisms possess a diversity of control mechanisms that detect deviations and make corrective actions. **(1.2c)**
- Cells have particular structures that perform specific jobs. These structures perform the actual work of the cell. Just as systems are coordinated and work together, cell parts must also be coordinated and work together. **(1.2f)**
- The structures present in some single-celled organisms act in a manner similar to the tissues and systems found in multicellular organisms, thus enabling them to perform all of the life processes needed to maintain homeostasis. **(1.3a)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Standard 7: Interdisciplinary Problem Solving

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- Patterns observable at one scale may not be observable or exist at other scales.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- 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.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

- Many organic and inorganic substances dissolved in cells allow necessary chemical reactions to take place in order to maintain life. Large organic food molecules such as proteins and starches must initially be broken down (digested to amino acids and simple sugars respectively), in order to enter cells. Once nutrients enter a cell, the cell will use them as building blocks in the synthesis of compounds necessary for life. **(1.2h)**
- Receptor molecules play an important role in the interactions between cells. Two primary agents of cellular communication are hormones and chemicals produced by nerve cells. If nerve or hormone signals are blocked, cellular communication is disrupted and the organism's stability is affected. **(1.2j)**
- In all organisms, organic compounds can be used to assemble other molecules such as proteins, DNA, starch, and fats. The chemical energy stored in bonds can be used as a source of energy for life processes. **(5.1c)**
- Biochemical processes, both breakdown and synthesis, are made possible by a large set of biological catalysts called enzymes. Enzymes can affect the rates of chemical change. The rate at which enzymes work can be influenced by internal environmental factors such as pH and temperature. **(5.1f)**
- Enzymes and other molecules, such as hormones, receptor molecules, and antibodies, have specific shapes that influence both how they function and how they interact with other molecules. **(5.1g)**
- The energy for life comes primarily from the Sun. Photosynthesis provides a vital connection between the Sun and the energy needs of living systems. **(5.1a)**
- Plant cells and some one-celled organisms contain chloroplasts, the site of photosynthesis. The process of photosynthesis uses solar energy to combine the inorganic molecules carbon dioxide and water into energy-rich organic compounds (e.g., glucose) and release oxygen to the environment. **(5.1b)**
- In all organisms, the energy stored in organic molecules may be released during cellular respiration. This energy is temporarily stored in ATP molecules. In many organisms, the process of cellular respiration is concluded in mitochondria, in which ATP is produced more efficiently, oxygen is used, and carbon dioxide and water are released as wastes. **(5.1d)**
- The energy from ATP is used by the organism to obtain, transform, and transport materials, and to eliminate wastes. **(5.1e)**
- Reproduction and development are necessary for the continuation of any species. **(4.1a)**
- Some organisms reproduce asexually with all the genetic information coming from one parent. Other organisms reproduce sexually with half the genetic information typically contributed by each parent. Cloning is the production of identical genetic copies. **(4.1b)**

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.9-10.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 9–10 texts and topics.

WHST.9-10.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.5: 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.

WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.2: The Living Environment

- Guideline C—Systems and connections—Learners understand the living environment to be comprised of interrelated, dynamic systems.
- Guideline D—Flow of matter and energy—Learners are able to account for environmental characteristics based on their knowledge of how matter and energy interact in living systems.

LE Unit 4 Homeostasis and Immunity

RECOMMENDED TIME: 25 DAYS

Unit Overview:

The components of living systems, from a single cell to an ecosystem, interact to maintain balance. Different organisms have different regulatory mechanisms that function to maintain the level of organization necessary for life. Because organisms are continually exposed to changes in their external and internal environments, they must continually monitor and respond to these changes. Responses to change can range in complexity from simple activation of a cell chemical process to elaborate learned behavior. The result of these responses is called homeostasis, a "dynamic equilibrium" or "steady state" that keeps the internal environment within certain limits. Organisms have a diversity of homeostatic feedback mechanisms that detect deviations from normal and take corrective actions to return their systems to the normal range. These mechanisms maintain the internal environment within narrow limits that are favorable for cell activities. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:
How do we survive?

Key Ideas:

Key Idea 1: Living things are both similar to and different from each other and from nonliving things.

Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (1.2a-e, j, 1.3a, 5.2a-h, j, 5.3a, b)

- The organs and systems of the body help to provide all the cells with their basic needs. The cells of the body are of different kinds and are grouped in ways that enhance how they function together. **(1.2e)**
- Important levels of organization for structure and function include organelles, cells, tissues, organs, organ systems, and whole organisms. **(1.2a)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

- Humans are complex organisms. They require multiple systems for digestion, respiration, reproduction, circulation, excretion, movement, coordination, and immunity. The systems interact to perform the life functions. **(1.2b)**
- The components of the human body, from organ systems to cell organelles, interact to maintain a balanced internal environment. To successfully accomplish this, organisms possess a diversity of control mechanisms that detect deviations and make corrective actions. **(1.2c)**
- The structures present in some single-celled organisms act in a manner similar to the tissues and systems found in multicellular organisms, thus enabling them to perform all of the life processes needed to maintain homeostasis. **(1.3a)**
- If there is a disruption in any human system, there may be a corresponding imbalance in homeostasis. **(1.2d)**
- Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death. **(5.2a)**
- Viruses, bacteria, fungi, and other parasites may infect plants and animals and interfere with normal life functions. **(5.2b)**
- Disease may also be caused by inheritance, toxic substances, poor nutrition, organ malfunction, and some personal behavior. Some effects show up right away; others may not show up for many years. **(5.2h)**
- Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals. **(5.2j)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Key Idea 4: Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Standard 7: Interdisciplinary Problem Solving

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.
- Changes in systems may have various causes that may not have equal effects.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- Patterns observable at one scale may not be observable or exist at other scales.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

- Dynamic equilibrium results from detection of and response to stimuli. Organisms detect and respond to change in a variety of ways both at the cellular level and at the organismal level. **(5.3a)**
- Feedback mechanisms have evolved that maintain homeostasis. Examples include the changes in heart rate or respiratory rate in response to increased activity in muscle cells, the maintenance of blood sugar levels by insulin from the pancreas, and the changes in openings in the leaves of plants by guard cells to regulate water loss and gas exchange. **(5.3b)** 🍃
- Receptor molecules play an important role in the interactions between cells. Two primary agents of cellular communication are hormones and chemicals produced by nerve cells. If nerve or hormone signals are blocked, cellular communication is disrupted and the organism's stability is affected. **(1.2j)** 🍃
- The immune system protects against antigens associated with pathogenic organisms or foreign substances and some cancer cells. **(5.2c)** 🍃
- Some white blood cells engulf invaders. Others produce antibodies that attack them or mark them for killing. Some specialized white blood cells will remain, able to fight off subsequent invaders of the same kind. **(5.2d)**
- Vaccinations use weakened microbes (or parts of them) to stimulate the immune system to react. This reaction prepares the body to fight subsequent invasions by the same microbes. **(5.2e)**
- Some viral diseases, such as AIDS, damage the immune system, leaving the body unable to deal with multiple infectious agents and cancerous cells. **(5.2f)**
- Some allergic reactions are caused by the body's immune responses to usually harmless environmental substances. Sometimes the immune system may attack some of the body's own cells or transplanted organs. **(5.2g)**

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- 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.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

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

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.9-10.2: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

RST.9-10.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 9–10 texts and topics.

WHST.9-10.2 : Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.5: 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.

WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 1: Questioning, Analysis, and Interpretation Skills

- Guideline A—Questioning—Learners are able to develop questions that help them learn about the environment and do simple investigations.
- Guideline B—Designing investigations—Learners are able to design simple investigations.
- Guideline C—Collecting information—Learners are able to locate and collect information about the environment and environmental topics.
- Guideline D—Evaluating accuracy and reliability—Learners understand the need to use reliable information to answer their questions. They are familiar with some basic factors to consider in judging the merits of information.
- Guideline E—Organizing information—Learners are able to describe data and organize information to search for relationships and patterns concerning the environment and environmental topics.
- Guideline G—Drawing conclusions and developing explanations—Learners can develop simple explanations that address their questions about the environment.

LE | Unit 5 Reproduction and Development

RECOMMENDED TIME: 20 DAYS

Unit Overview:

Species transcend individual life spans through reproduction. Asexual reproduction produces genetically identical offspring. Sexual reproduction produces offspring that have a combination of genes inherited from each parent's specialized sex cells (gametes). The processes of gamete production, fertilization, and development follow an orderly sequence of events. Zygotes contain all the information necessary for growth, development, and eventual reproduction of the organism. Development is a highly regulated process involving mitosis and differentiation. Reproduction and development are subject to environmental impact. Human development, birth, and aging should be viewed as a predictable pattern of events. Reproductive technology has medical, agricultural, and ecological applications. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:
How does life create life?

Key Ideas:

Key Idea 2: Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Key Idea 4: The continuity of life is sustained through reproduction and development.

NYS SCIENCE STANDARDS
http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (2.1d, e; 4.1a-h)

- The processes of meiosis and fertilization are key to sexual reproduction in a wide variety of organisms. The process of meiosis results in the production of eggs and sperm which each contain half of the genetic information. During fertilization, gametes unite to form a zygote, which contains the complete genetic information for the offspring. **(4.1c)**
- In asexually reproducing organisms, all the genes come from a single parent. Asexually produced offspring are normally genetically identical to the parent. **(2.1d)**

continued

MST STANDARDS
http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

NGSS CROSS-CUTTING CONCEPTS
http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.
- Changes in systems may have various causes that may not have equal effects.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

- Reproduction and development are necessary for the continuation of any species. **(4.1a)** 🍃
- Human reproduction and development are influenced by factors such as gene expression, hormones, and the environment. The reproductive cycle in both males and females is regulated by hormones such as testosterone, estrogen, and progesterone. **(4.1e)** 🍃
- The structures and functions of the human female reproductive system, as in almost all other mammals, are designed to produce gametes in ovaries, allow for internal fertilization, support the internal development of the embryo and fetus in the uterus, and provide essential materials through the placenta, and nutrition through milk for the newborn. **(4.1f)**
- The structures and functions of the human male reproductive system, as in other mammals, are designed to produce gametes in testes and make possible the delivery of these gametes for fertilization. **(4.1g)**
- In sexually reproducing organisms, the new individual receives half of the genetic information from its mother (via the egg) and half from its father (via the sperm). Sexually produced offspring often resemble, but are not identical to, either of their parents. **(2.1e)**
- The processes of meiosis and fertilization are key to sexual reproduction in a wide variety of organisms. The process of meiosis results in the production of eggs and sperm which each contain half of the genetic information. During fertilization, gametes unite to form a zygote, which contains the complete genetic information for the offspring. **(4.1c)**
- The zygote may divide by mitosis and differentiate to form the specialized cells, tissues, and organs of multicellular organisms. **(4.1d)**
- In humans, the embryonic development of essential organs occurs in early stages of pregnancy. The embryo may encounter risks from faults in its genes and from its mother's exposure to environmental factors such as inadequate diet, use of alcohol/drugs/tobacco, other toxins, or infections throughout her pregnancy. **(4.1h)** 🍃

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- 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.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.9-10.5: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

WHST.9-10.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.9-10.5: 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.

WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.4: Environment and Society

- Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs.

LE | Unit 6 Genetics and Biotechnology

RECOMMENDED TIME: 25 DAYS

Unit Overview:

Organisms from all kingdoms possess a set of instructions (genes) that determines their characteristics. These instructions are passed from parents to offspring during reproduction. The inherited instructions that are passed from parent to offspring exist in the form of a code. This code is contained in DNA molecules. The DNA molecules must be accurately replicated before being passed on. Once the coded information is passed on, it is used by a cell to make proteins. The proteins that are made become cell parts and carry out most functions of the cell. Throughout recorded history, humans have used selective breeding and other biotechnological methods to produce products or organisms with desirable traits. Our current understanding of DNA extends this to the manipulation of genes leading to the development of new combinations of traits and new varieties of organisms. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:

Why do offspring look like their parents?

Key Ideas:

Key Idea 2: Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (2.1a-c, f-k; 2.2a-e; 5.2h, i)

- Genes are inherited, but their expression can be modified by interactions with the environment. **(2.1a)**
- Every organism requires a set of coded instructions for specifying its traits. For offspring to resemble their parents there must be a reliable way to transfer information from one generation to the next. Heredity is the passage of these instructions from one generation to another. **(2.1b)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Empirical evidence is needed to identify patterns.

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Systems can be designed to cause a desired effect.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

- Hereditary information is contained in genes, located in the chromosomes of each cell. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes in its nucleus. **(2.1c)**
- In all organisms, the coded instructions for specifying the characteristics of the organism are carried in DNA, a large molecule formed from subunits arranged in a sequence with bases of four kinds (represented by A, G, C, and T). The chemical and structural properties of DNA are the basis for how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "bases") and replicated by means of a template. **(2.1f)**
- Cells store and use coded information. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires. **(2.1g)**
- The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins. Protein molecules are long, usually folded chains made from 20 different kinds of amino acids in a specific sequence. This sequence influences the shape of the protein. The shape of the protein, in turn, determines its function. **(2.1i)**
- Offspring resemble their parents because they inherit similar genes that code for the production of proteins that form similar structures and perform similar functions. **(2.1j)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Key Idea 4: Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Key Idea 6: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- Changes in systems may have various causes that may not have equal effects.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems can be designed to do specific tasks.
- 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.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- 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.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf**		**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
▪ The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. This is because different parts of these instructions are used in different types of cells, and are influenced by the cell's environment and past history. **(2.1k)** 🍃 ▪ Knowledge of genetics is making possible new fields of health care; for example, finding genes which may have mutations that can cause disease will aid in the development of preventive measures to fight disease. Substances, such as hormones and enzymes, from genetically engineered organisms may reduce the cost and side effects of replacing missing body chemicals. **(2.2e)** ▪ Disease may also be caused by inheritance, toxic substances, poor nutrition, organ malfunction, and some personal behavior. Some effects show up right away; others may not show up for many years. **(5.2h)** 🍃 ▪ Genes are segments of DNA molecules. Any alteration of the DNA sequence is a mutation. Usually, an altered gene will be passed on to every cell that develops from it. **(2.1h)** ▪ Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. **(2.2d)** ▪ Gene mutations in a cell can result in uncontrolled cell division, called cancer. Exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer. **(5.2i)** 🍃		▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.9-10.2: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

RST.9-10.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 9–10 texts and topics.

RST.9-10.5: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

WHST.9-10.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.5: 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.

WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2.2: The Living Environment

- Guideline B—Heredity and evolution—Learners understand the basic ideas and genetic mechanisms behind biological evolution.

Strand 2.4: Environment and Society

- Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs.
- Guideline D—Technology—Learners are able to examine the social and environmental impacts of various technologies and technological systems.

LE | Unit 7 Evolution

RECOMMENDED TIME: 15 DAYS

Unit Overview:

Evolution is the change of species over time. This theory is the central unifying theme of biology. This change over time is well documented by extensive evidence from a wide variety of sources. In sexually reproducing organisms, only changes in the genes of sex cells can become the basis for evolutionary change and that these evolutionary changes may occur in structure, function, and behavior over time. Students need to be able to distinguish between evolutionary change and the changes that occur during the lifetime of an individual organism. According to many scientists, biological evolution occurs through natural selection. Natural selection is the result of overproduction of offspring, variations among offspring, the struggle for survival, the adaptive value of certain variations, and the subsequent survival and increased reproduction of those best adapted to a particular environment. Selection for individuals with a certain trait can result in changing the proportions of that trait in a population. The diversity of life on Earth today is the result of natural selection occurring over a vast amount of geologic time for most organisms, but over a short amount of time for organisms with short reproductive cycles such as pathogens in an antibiotic environment and insects in a pesticide environment. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:
Is change inevitable for all living things?

Key Ideas:

Key Idea 3: Individual organisms and species change over time.

NYS SCIENCE STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf	MST STANDARDS http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf	NGSS CROSS-CUTTING CONCEPTS http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
Major Understandings: *Quoted from the New York State Performance Indicators (3.1a-l, 6.2a)* ■ The basic theory of biological evolution states that the Earth's present-day species developed from earlier, distinctly different species. **(3.1a)** ■ New inheritable characteristics result from new combinations of existing genes or from mutations of genes in reproductive cells. **(3.1b)** *continued*	**Standard 6: Interconnectedness—Common Themes** **Key Idea 5:** Identifying patterns of change is necessary for making predictions about future behavior and conditions.	**Patterns:** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. ■ 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. ■ Empirical evidence is needed to identify patterns. *continued*

NYS SCIENCE STANDARDS

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- Mutation and the sorting and recombining of genes during meiosis and fertilization result in a great variety of possible gene combinations. **(3.1c)**
- Mutations occur as random chance events. Gene mutations can also be caused by such agents as radiation and chemicals. When they occur in sex cells, the mutations can be passed on to offspring; if they occur in other cells, they can be passed on to other body cells only. **(3.1d)** 🍃
- Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life-forms, as well as for the molecular and structural similarities observed among the diverse species of living organisms. **(3.1e)**
- Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring. **(3.1f)** 🍃
- Some characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase. **(3.1g)**
- The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions. **(3.1h)** 🍃
- Behaviors have evolved through natural selection. The broad patterns of behavior exhibited by organisms are those that have resulted in greater reproductive success. **(3.1i)**
- Billions of years ago, life on Earth is thought by many scientists to have begun as simple, single-celled organisms. About a billion years ago, increasingly complex multicellular organisms began to evolve. **(3.1j)**
- Evolution does not necessitate long-term progress in some set direction. Evolutionary changes appear to be like the growth of a bush: Some branches survive from the beginning with little or no change, many die out altogether, and others branch repeatedly, sometimes giving rise to more complex organisms. **(3.1k)**
- Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on Earth no longer exist. **(3.1l)** 🍃
- As a result of evolutionary processes, there is a diversity of organisms and roles in ecosystems. This diversity of species increases the chance that at least some will survive in the face of large environmental changes. Biodiversity increases the stability of the ecosystem. **(6.2a)** 🍃

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

COMMON CORE STATE STANDARDS

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http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.9-10.2: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

WHST.9-10.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.5: 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.

WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

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Strand 2.2: The Living Environment

- Guideline A—Organisms, populations, and communities—Learners understand basic population dynamics and the importance of diversity in living systems.
- Guideline B—Heredity and evolution—Learners understand the basic ideas and genetic mechanisms behind biological evolution.

Strand 2.4: Environment and Society

- Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs.

Strand 3.1: Skills for Analyzing and Investigating Environmental Issues

- Guideline B—Sorting out the consequences of issues—Learners are able to evaluate the consequences of specific environmental changes, conditions, and issues for human and ecological systems.

LE Unit 8 Human Influences on the Environment

RECOMMENDED TIME: 10 DAYS

Unit Overview:

Population growth has placed new strains on the environment—massive pollution of air and water, deforestation and extinction of species, global warming, and alteration of the ozone shield. Some individuals believe that there will be a technological fix for such problems. Others, concerned with the accelerating pace of change and the ecological concept of finite resources, are far less optimistic. What is certain, however, is that resolving these issues will require increasing global awareness, cooperation, and action. Since the students of today will be the elected officials and informed public of tomorrow, the teacher should encourage a diversity of activities that will allow students to explore, explain, and apply conceptual understandings and skills necessary to be environmentally literate. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:

Why do we need to care for our planet?

Key Ideas:

Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (7.1a-c, 7.2a-c, 7.3a, c)

- The Earth has finite resources; increasing human consumption of resources places stress on the natural processes that renew some resources and deplete those resources that cannot be renewed. **(7.1a)**
- Natural ecosystems provide an array of basic processes that affect humans. Those processes include but are not limited to: maintenance of the quality of the atmosphere, generation of soils, control of the water cycle, removal of wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental. **(7.1b)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.

Key Idea 3: Information technology can have positive and negative impacts on society, depending upon how it is used.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Empirical evidence is needed to identify patterns.

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/livingen.pdf

- Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected. **(7.1c)**
- Human activities that degrade ecosystems result in a loss of diversity of the living and nonliving environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species, and pollution changes the chemical composition of air, soil, and water. **(7.2a)**
- When humans alter ecosystems either by adding or removing specific organisms, serious consequences may result. For example, planting large expanses of one crop reduces the biodiversity of the area. **(7.2b)**
- Industrialization brings an increased demand for and use of energy and other resources including fossil and nuclear fuels. This usage can have positive and negative effects on humans and ecosystems. **(7.2c)**
- Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs. **(7.3a)**
- The decisions of one generation both provide and limit the range of possibilities open to the next generation. **(7.3b)**

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/mststa1_2.pdf
http://www.p12.nysed.gov/ciai/mst/pub/mststa6_7.pdf

Key Idea 4: Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Key Idea 6: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
- Feedback (negative or positive) can stabilize or destabilize a system.
- Systems can be designed for greater or lesser stability.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.
- Systems can be designed to cause a desired effect.
- Changes in systems may have various causes that may not have equal effects.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.
- 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.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

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.

WHST.9-10.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.5: 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.

WHST.9-10.6: Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

WHST.9-10.8: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

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Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.3: Humans and Their Societies

- Guideline A—Individuals and groups—Learners understand the influence of individual and group actions on the environment, and how groups can work to promote and balance interests.

Strand 2.4: Environment and Society

- Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs.
- Guideline D—Technology—Learners are able to examine the social and environmental impacts of various technologies and technological systems.
- Guideline E—Environmental issues—Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that these scales and issues are often linked.

Strand 3: Skills for Understanding and Addressing Environmental Issues

Strand 3.1: Skills for Analyzing and Investigating Environmental Issues

- Guideline A—Identifying and investigating issues—Learners apply their research and analytical skills to investigate environmental issues ranging from local issues to those that are regional or global in scope.
- Guideline B—Sorting out the consequences of issues—Learners are able to evaluate the consequences of specific environmental changes, conditions, and issues for human and ecological systems.
- Guideline C—Identifying and evaluating alternative solutions and courses of action—Learners are able to identify and propose action strategies that are likely to be effective in particular situations and for particular purposes.
- Guideline D—Working with flexibility, creativity, and openness—While environmental issues investigations can bring to the surface deeply held views, learners are able to engage each other in peer review conducted in the spirit of open inquiry.

continued

	ENVIRONMENTAL GUIDELINES FOR LEARNING http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf
	Strand 3.2: **Decision-Making and Citizenship Skills** ▪ Guideline A—Forming and evaluating personal views—Learners are able to examine and express their own views on environmental issues. ▪ Guideline B—Evaluating the need for citizen action—Learners are able to think critically about whether they believe action is needed in particular situations and whether they believe they should be involved. ▪ Guideline C—Planning and taking action—By participating in issues of their choosing—mostly close to home—they learn the basics of individual and collective action. ▪ Guideline D—Evaluating the results of actions—Learners understand that civic actions have consequences.

ES

Earth Science

ES Unit 1

Maps and Measurement

RECOMMENDED TIME: 17 DAYS

Unit Overview:

Theories of the universe have developed over many centuries. Although to a casual observer celestial bodies appeared to orbit a stationary Earth, scientific discoveries led us to the understanding that Earth is one planet that orbits the Sun, a typical star in a vast and ancient universe. We now infer an origin and an age and evolution of the universe, as we speculate about its future. As we look at Earth, we find clues to its origin and how it has changed through nearly five billion years, as well as the evolution of life on Earth.

Essential Question:

How can we produce good models of the Earth?

Key Ideas:

Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (1.1b-e, g; 1.2a-c; 2.1q)

- Nine planets move around the Sun in nearly circular orbits. **(1.1b)**
  - — Earth is orbited by one moon and many artificial satellites.
- Earth's coordinate system of latitude and longitude, with the equator and prime meridian as reference lines, is based upon Earth's rotation and our observation of the Sun and stars. **(1.1c)**
- Earth rotates on an imaginary axis at a rate of 15 degrees per hour. To people on Earth, this turning of the planet makes it seem as though the Sun, the moon, and the stars are moving around Earth once a day. Rotation provides a basis for our system of local time; meridians of longitude are the basis for time zones. **(1.1d)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Standard 2: Information Systems

Students will access, generate, process, and transfer information using appropriate technologies.

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.

Standard 6: Interconnectedness: Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- Patterns observable at one scale may not be observable or exist at other scales.
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
▪ The Foucault pendulum and the Coriolis effect provide evidence of Earth's rotation. **(1.1e)** ▪ Seasonal changes in the apparent positions of constellations provide evidence of Earth's revolution. **(1.1g)** ▪ The universe is vast and estimated to be over ten billion years old. The current theory is that the universe was created from an explosion called the Big Bang. **(1.2a)** ▪ Stars form when gravity causes clouds of molecules to contract until nuclear fusion of light elements into heavier ones occurs. Fusion releases great amounts of energy over millions of years. **(1.2b)** — Our Sun is a medium-sized star within a spiral galaxy of stars known as the Milky Way. Our galaxy contains billions of stars, and the universe contains billions of such galaxies. ▪ Our solar system formed about five billion years ago from a giant cloud of gas and debris. Gravity caused Earth and the other planets to become layered according to density differences in their materials. **(1.2c)** ▪ • Topographic maps represent landforms through the use of contour lines that are isolines connecting points of equal elevation. Gradients and profiles can be determined from changes in elevation over a given distance. **(2.1q)**	**Key Idea 2:** Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design. **Key Idea 3:** The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. **Standard 7: Interdisciplinary Problem Solving** Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions. **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.	▪ 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. ▪ Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

COMMON CORE STATE STANDARDS **http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf** **http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf**	**ENVIRONMENTAL GUIDELINES FOR LEARNING** **http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf**	**TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/EARTH SCIENCE THAT ARE RELEVANT TO THE UNIT** **http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf**
ELA/Literacy **RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **WHST.9-10.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.9-10.5:** 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. **WHST.9-10.9:** Draw evidence from informational texts to support analysis, reflection, and research. **Mathematics** **HSN.Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN.Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN.Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	**Strand 1: Questioning, Analysis, and Interpretation Skills** ▪ Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena. ▪ Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses. **Strand 3: Skills for Understanding and Addressing Environmental Issues** **Strand 3.1: Skills for Analyzing and Investigating Environmental Issues** ▪ Guideline A—Identifying and investigating issues—Learners apply their research and analytical skills to investigate environmental issues ranging from local issues to those that are regional or global in scope.	*[Refer to Appendix C – Reference Tables for Physical Setting/Earth Science]* Equations (p1)

ES | Unit 2 Dynamic Earth

RECOMMENDED TIME: 18 DAYS

Unit Overview:

Earth may be considered a huge machine driven by two engines, one internal and one external. These heat engines convert heat energy into mechanical energy. Earth's internal heat engine is powered by heat from the decay of radioactive materials and residual heat from Earth's formation. Differences in density resulting from heat flow within Earth's interior caused the changes explained by the theory of plate tectonics: movement of the lithospheric plates; earthquakes; volcanoes; and the deformation and metamorphism of rocks during the formation of young mountains.

Essential Question:
What makes the Earth dynamic?

Key Ideas:

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (2.1a, b, j-p)

- Earth systems have internal and external sources of energy, both of which create heat. **(2.1a)**
- The transfer of heat energy within the atmosphere, the hydrosphere, and Earth's interior results in the formation of regions of different densities. These density differences result in motion. **(2.1b)**
- Properties of Earth's internal structure (crust, mantle, inner core, and outer core) can be inferred from the analysis of the behavior of seismic waves (including velocity and refraction). **(2.1j)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.

Key Idea 3: Information technology can have positive and negative impacts on society, depending upon how it is used.

Standard 6: Interconnectedness: Common Themes

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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 of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.
- Empirical evidence is needed to identify patterns.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
— Analysis of seismic waves allows the determination of the location of earthquake epicenters, and the measurement of earthquake magnitude; this analysis leads to the inference that Earth's interior is composed of layers that differ in composition and states of matter. ▪ The outward transfer of Earth's internal heat drives convective circulation in the mantle that moves the lithospheric plates comprising Earth's surface. **(2.1k)** ▪ The lithosphere consists of separate plates that ride on the more fluid asthenosphere and move slowly in relationship to one another, creating convergent, divergent, and transform plate boundaries. These motions indicate Earth is a dynamic geologic system. **(2.1l)** — These plate boundaries are the sites of most earthquakes, volcanoes, and young mountain ranges. — Compared to continental crust, ocean crust is thinner and denser. New ocean crust continues to form at mid-ocean ridges. — Earthquakes and volcanoes present geologic hazards to humans. Loss of property, personal injury, and loss of life can be reduced by effective emergency preparedness. ▪ Many processes of the rock cycle are consequences of plate dynamics. These include the production of magma (and subsequent igneous rock formation and contact metamorphism) at both subduction and rifting regions, regional metamorphism within subduction zones, and the creation of major depositional basins through down-warping of the crust. **(2.1m)** *continued*	**Standard 7: Interdisciplinary Problem Solving** **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.	**Cause and Effect: Mechanism and Prediction:** Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. ▪ Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ▪ Systems can be designed to cause a desired effect. ▪ Changes in systems may have various causes that may not have equal effects. **Scale, Proportion, and Quantity:** In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change ▪ The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ▪ Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. **Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ▪ Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. *continued*

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf**		**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
▪ Many of Earth's surface features such as mid-ocean ridges/rifts, trenches/subduction zones/island arcs, mountain ranges (folded, faulted, and volcanic), hot spots, and the magnetic and age patterns in surface bedrock are a consequence of forces associated with plate motion and interaction. **(2.1n)** ▪ Plate motions have resulted in global changes in geography, climate, and the patterns of organic evolution. **(2.1o)** 🍃 ▪ Landforms are the result of the interaction of tectonic forces and the processes of weathering, erosion, and deposition. **(2.1p)** 🍃		**Energy and Matter: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior. ▪ Energy drives the cycling of matter within and between systems. **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. ▪ Much of science deals with constructing explanations of how things change and how they remain stable. ▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

COMMON CORE STATE STANDARDS **http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf** **http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf**	**ENVIRONMENTAL GUIDELINES FOR LEARNING** **http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf**	**TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/EARTH SCIENCE THAT ARE RELEVANT TO THE UNIT** **http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf**
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ES | Unit 3 Rocks and Minerals

RECOMMENDED TIME: 15 DAYS

Unit Overview:

Observation and classification have helped us understand the great variety and complexity of Earth materials. Minerals are the naturally occurring inorganic solid elements, compounds, and mixtures from which rocks are made. We classify minerals on the basis of their chemical composition and observable properties. Rocks are generally classified by their origin (igneous, metamorphic, and sedimentary), texture, and mineral content. Rocks and minerals help us understand Earth's historical development and its dynamics. They are important to us because of their availability and properties. The use and distribution of mineral resources and fossil fuels have important economic and environmental impacts. As limited resources, they must be used wisely.

Essential Question:
How do rocks change over time?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (1.2f, 2.1m, v, w; 3.1a-c)

- Minerals have physical properties determined by their chemical composition and crystal structure. **(3.1a)**
  - — Minerals can be identified by well-defined physical and chemical properties, such as cleavage, fracture, color, density, hardness, streak, luster, crystal shape, and reaction with acid.
  - — Chemical composition and physical properties determine how minerals are used by humans.

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

- Minerals are formed inorganically by the process of crystallization as a result of specific environmental conditions. These include: **(3.1b)** 🍃
  - — cooling and solidification of magma
  - — precipitation from water caused by such processes as evaporation, chemical reactions, and temperature changes
  - — rearrangement of atoms in existing minerals subjected to conditions of high temperature and pressure
- Rocks are usually composed of one or more minerals. **(3.1c)** 🍃
  - — Rocks are classified by their origin, mineral content, and texture.
  - — Conditions that existed when a rock formed can be inferred from the rock's mineral content and texture.
  - — The properties of rocks determine how they are used and also influence land usage by humans.
- Many processes of the rock cycle are consequences of plate dynamics. These include the production of magma (and subsequent igneous rock formation and contact metamorphism) at both subduction and rifting regions, regional metamorphism within subduction zones, and the creation of major depositional basins through down-warping of the crust. **(2.1m)**
- Earth's oceans formed as a result of precipitation over millions of years. The presence of an early ocean is indicated by sedimentary rocks of marine origin, dating back about four billion years. **(1.2f)** 🍃
- Patterns of deposition result from a loss of energy within the transporting system and are influenced by the size, shape, and density of the transported particles. Sediment deposits may be sorted or unsorted. **(2.1v)**
- Sediments of inorganic and organic origin often accumulate in depositional environments. Sedimentary rocks form when sediments are compacted and/or cemented after burial or as the result of chemical precipitation from seawater. **(2.1w)** 🍃

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- 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.
- Energy drives the cycling of matter within and between systems.

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- 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.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

COMMON CORE STATE STANDARDS http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf	ENVIRONMENTAL GUIDELINES FOR LEARNING http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf	TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/EARTH SCIENCE THAT ARE RELEVANT TO THE UNIT http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf
ELA/Literacy **RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **WHST.9-10.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.9-10.5:** 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. **WHST.9-10.9:** Draw evidence from informational texts to support analysis, reflection, and research. **Mathematics** **HSN.Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN.Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN.Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN.Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN.Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	**Strand 2: Knowledge of Environmental Processes and Systems** **Strand 2.1: The Earth as a Physical System** ■ Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth. ■ Guideline B—Changes in matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena. ■ Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them. **Strand 2.4: Environment and Society** ■ Guideline C—Resources—Learners understand that the importance and use of resources change over time and vary under different economic and technological systems.	*[Refer to Appendix C – Reference Tables for Physical Setting/Earth Science]* Generalized Landscape of Regions of New York State (p2) Generalized Bedrock Geology of New York State (p3) Rock Cycle in Earth's Crust (p6) Scheme for Igneous Rock Identification (p6) Relationship of Transported Size to Water Velocity (p6) Scheme for Sedimentary Rock Identification (p7) Scheme for Metamorphic Rock Identification (p7) Geologic History of New York State (p8–9) Properties of Common Minerals (p16)

ES | Unit 4 Landscapes

RECOMMENDED TIME: 30 DAYS

Unit Overview:

Earth may be considered a huge machine driven by two engines, one internal and one external. These heat engines convert heat energy into mechanical energy. Precipitation resulting from the external heat engine's weather systems supplies moisture to Earth's surface that contributes to the weathering of rocks. Running water erodes mountains that were originally uplifted by Earth's internal heat engine and transports sediments to other locations, where they are deposited and may undergo the processes that transform them into sedimentary rocks. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:

Why does the land look different in different places?

Key Ideas:

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (1.1i; 1.2d; f, g; 2.1b, p, r-w, 3.1c)

- Earth has continuously been recycling water since the outgassing of water early in its history. This constant recirculation of water at and near Earth's surface is described by the hydrologic (water) cycle. **(1.2g)** 🍃
- Water is returned from the atmosphere to Earth's surface by precipitation. Water returns to the atmosphere by evaporation or transpiration from plants. A portion of the precipitation becomes runoff over the land or infiltrates into the ground to become stored in the soil or groundwater below the water table. Soil capillarity influences these processes.

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Standard 2: Information Systems

Students will access, generate, process, and transfer information using appropriate technologies.

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.

Key Idea 3: Information technology can have positive and negative impacts on society, depending upon how it is used.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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 of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

- The amount of precipitation that seeps into the ground or runs off is influenced by climate, slope of the land, soil, rock type, vegetation, land use, and degree of saturation.
- Porosity, permeability, and water retention affect runoff and infiltration.
- The transfer of heat energy within the atmosphere, the hydrosphere, and Earth's interior results in the formation of regions of different densities. These density differences result in motion. **(2.1b)**
- The natural agents of erosion include: **(2.1u)**
- *Streams (running water)*: Gradient, discharge, and channel shape influence a stream's velocity and the erosion and deposition of sediments. Sediments transported by streams tend to become rounded as a result of abrasion. Stream features include V-shaped valleys, deltas, flood plains, and meanders. A watershed is the area drained by a stream and its tributaries.
- *Glaciers (moving ice)*: Glacial erosional processes include the formation of U-shaped valleys, parallel scratches, and grooves in bedrock. Glacial features include moraines, drumlins, kettle lakes, finger lakes, and outwash plains.
- *Wave Action*: Erosion and deposition cause changes in shoreline features, including beaches, sandbars, and barrier islands. Wave action rounds sediments as a result of abrasion. Waves approaching a shoreline move sand parallel to the shore within the zone of breaking waves.
- *Wind*: Erosion of sediments by wind is most common in arid climates and along shorelines. Wind-generated features include dunes and sand-blasted bedrock.
- *Mass Movement*: Earth materials move downslope under the influence of gravity.

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Key Idea 6: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Standard 7: Interdisciplinary Problem Solving

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.
- Systems can be designed to cause a desired effect.
- Changes in systems may have various causes that may not have equal effects.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

- Approximately 70 percent of Earth's surface is covered by a relatively thin layer of water, which responds to the gravitational attraction of the moon and the Sun with a daily cycle of high and low tides. **(1.1i)** 🍃
- Earth's oceans formed as a result of precipitation over millions of years. The presence of an early ocean is indicated by sedimentary rocks of marine origin, dating back about four billion years. **(1.2f)**
- Climate variations, structure, and characteristics of bedrock influence the development of landscape features including mountains, plateaus, plains, valleys, ridges, escarpments, and stream drainage patterns. **(2.1r)** 🍃
- Weathering is the physical and chemical breakdown of rocks at or near Earth's surface. Soils are the result of weathering and biological activity over long periods of time. **(2.1s)** 🍃
- Natural agents of erosion, generally driven by gravity, remove, transport, and deposit weathered rock particles. Each agent of erosion produces distinctive changes in the material that it transports and creates characteristic surface features and landscapes. In certain erosional situations, loss of property, personal injury, and loss of life can be reduced by effective emergency preparedness. **(2.1t)** 🍃
- Patterns of deposition result from a loss of energy within the transporting system and are influenced by the size, shape, and density of the transported particles. Sediment deposits may be sorted or unsorted. **(2.1v)**
- Sediments of inorganic and organic origin often accumulate in depositional environments. Sedimentary rocks form when sediments are compacted and/or cemented after burial or as the result of chemical precipitation from seawater. **(2.1w)**
- Rocks are usually composed of one or more minerals. **(3.1c)** 🍃
    - — Rocks are classified by their origin, mineral content, and texture.
    - — Conditions that existed when a rock formed can be inferred from the rock's mineral content and texture.
    - — The properties of rocks determine how they are used and also influence land usage by humans.
- Asteroids, comets, and meteors are components of our solar system. **(1.2d)**
    - — Impact events have been correlated with mass extinction and global climatic change.
    - — Impact craters can be identified in Earth's crust.
- Landforms are the result of the interaction of tectonic forces and the processes of weathering, erosion, and deposition. **(2.1p)** 🍃

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- 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.
- Energy drives the cycling of matter within and between systems.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
- Systems can be designed for greater or lesser stability.

COMMON CORE STATE STANDARDS **http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf** **http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf**	**ENVIRONMENTAL GUIDELINES FOR LEARNING** **http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf**	**TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/EARTH SCIENCE THAT ARE RELEVANT TO THE UNIT** **http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf**
ELA/Literacy **RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **WHST.9-10.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.9-10.5:** 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. **WHST.9-10.9:** Draw evidence from informational texts to support analysis, reflection, and research. **Mathematics** **HSN.Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN.Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN.Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	**Strand 2: Knowledge of Environmental Processes and Systems** **Strand 2.1: The Earth as a Physical System** ▪ Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth. ▪ Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them. **Strand 2.4: Environment and Society** ▪ Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs. ▪ Guideline B—Places—Learners understand “place” as humans endowing a particular part of the Earth with meaning through their interactions with that environment. ▪ Guideline E—Environmental issues—Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that these scales and issues are often linked.	*[Refer to Appendix C – Reference Tables for Physical Setting/Earth Science]* Generalized Landscape Regions of New York State (p2) Generalized Bedrock Geology of New York State (p3) Relationship of Transported Particle Size to Water Velocity (p6)

ES | Unit 5 Earth History

RECOMMENDED TIME: 12 DAYS

Unit Overview:

Theories of the universe have developed over many centuries. Although to a casual observer celestial bodies appeared to orbit a stationary Earth, scientific discoveries led us to the understanding that Earth is one planet that orbits the Sun, a typical star in a vast and ancient universe. We now infer an origin and an age and evolution of the universe, as we speculate about its future. As we look at Earth, we find clues to its origin and how it has changed through nearly five billion years, as well as the evolution of life on Earth.

Essential Question:

How do we know that the Earth has changed over time?

Key Ideas:

Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (1.2d, f, h-j; 2.1o)

- Asteroids, comets, and meteors are components of our solar system. **(1.2d)**
  - — Impact events have been correlated with mass extinction and global climatic change.
  - — Impact craters can be identified in Earth's crust.
- Earth's oceans formed as a result of precipitation over millions of years. The presence of an early ocean is indicated by sedimentary rocks of marine origin, dating back about four billion years. **(1.2f)**
- The evolution of life caused dramatic changes in the composition of Earth's atmosphere. Free oxygen did not form in the atmosphere until oxygen-producing organisms evolved. **(1.2h)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Empirical evidence is needed to identify patterns.

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

- The pattern of evolution of life-forms on Earth is at least partially preserved in the rock record. **(1.2i)** 🍃
  - Fossil evidence indicates that a wide variety of life-forms has existed in the past and that most of these forms have become extinct.
  - Human existence has been very brief compared to the expanse of geologic time.
- Geologic history can be reconstructed by observing sequences of rock types and fossils to correlate bedrock at various locations. **(1.2j)** 🍃
  - The characteristics of rocks indicate the processes by which they formed and the environments in which these processes took place.
  - Fossils preserved in rocks provide information about past environmental conditions.
  - Geologists have divided Earth history into time units based upon the fossil record.
  - Age relationships among bodies of rocks can be determined using principles of original horizontality, superposition, inclusions, cross-cutting relationships, contact metamorphism, and unconformities. The presence of volcanic ash layers, index fossils, and meteoritic debris can provide additional information.
  - The regular rate of nuclear decay (half-life time period) of radioactive isotopes allows geologists to determine the absolute age of materials found in some rocks.
- Plate motions have resulted in global changes in geography, climate, and the patterns of organic evolution. **(2.1o)** 🍃

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.
- 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.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

WHST.9-10.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.5: 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.

WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth.
- Guideline B—Changes in matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena.
- Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.

Strand 2.4: Environment and Society

- Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs.
- Guideline B—Places—Learners understand "place" as humans endowing a particular part of the Earth with meaning through their interactions with that environment.
- Guideline E—Environmental issues—Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that these scales and issues are often linked.

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/EARTH SCIENCE THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf

[Refer to Appendix C – Reference Tables for Physical Setting/Earth Science]

Radioactive Decay Data (p1)

Generalized Landscape of Regions of New York State (p2)

Generalized Bedrock Geology of New York State (p3)

Scheme for Igneous Rock Identification (p6)

Scheme for Sedimentary Rock Identification (p7)

Scheme for Metamorphic Rock Identification (p7)

Geologic History of New York State (p8–9)

ES | Unit 6 Insolation

RECOMMENDED TIME: 13 DAYS

Unit Overview:

Earth may be considered a huge machine driven by two engines, one internal and one external. These heat engines convert heat energy into mechanical energy. Earth's external heat engine is powered primarily by solar energy and influenced by gravity. Nearly all the energy for circulating the atmosphere and oceans is supplied by the Sun. As insolation strikes the atmosphere, a small percentage is directly absorbed, especially by gases such as ozone, carbon dioxide, and water vapor. Clouds and Earth's surface reflect some energy back to space, and Earth's surface absorbs some energy. Energy is transferred between Earth's surface and the atmosphere by radiation, conduction, evaporation, and convection. Temperature variations within the atmosphere cause differences in density that cause atmospheric circulation, which is affected by Earth's rotation. The interaction of these processes results in the complex atmospheric occurrence known as weather. Average temperatures on Earth are the result of the total amount of insolation absorbed by Earth's surface and its atmosphere and the amount of long-wave energy radiated back into space.

Essential Question:

How does the Sun affect our life on Earth?

Key Ideas:

Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective.

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (1.1a, f, h, 1.2e, 2.1b, i, 2.2a, b)

- Most objects in the solar system are in regular and predictable motion. **(1.1a)**
    - — These motions explain such phenomena as the day, the year, seasons, phases of the moon, eclipses, and tides.

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Standard 2: Information Systems

Students will access, generate, process, and transfer information using appropriate technologies.

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Empirical evidence is needed to identify patterns.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

  - Gravity influences the motions of celestial objects. The force of gravity between two objects in the universe depends on their masses and the distance between them.
- The Sun's apparent path through the sky varies with latitude and season. **(1.1h)**
- Insolation (solar radiation) heats Earth's surface and atmosphere unequally due to variations in: **(2.2a)**
  - the intensity caused by differences in atmospheric transparency and angle of incidence which vary with time of day, latitude, and season
  - Characteristics of the materials absorbing the energy such as color, texture, transparency, state of matter, and specific heat
  - duration, which varies with seasons and latitude
- Earth's changing position with regard to the Sun and the moon has noticeable effects. **(1.1f)**
  - Earth revolves around the Sun with its rotational axis tilted at 23.5 degrees to a line perpendicular to the plane of its orbit, with the North Pole aligned with Polaris.
  - During Earth's one-year period of revolution, the tilt of its axis results in changes in the angle of incidence of the Sun's rays at a given latitude; these changes cause variation in the heating of the surface. This produces seasonal variation in weather.
- Earth's early atmosphere formed as a result of the outgassing of water vapor, carbon dioxide, nitrogen, and lesser amounts of other gases from its interior. **(1.2e)**
- The transfer of heat energy within the atmosphere, the hydrosphere, and Earth's interior results in the formation of regions of different densities. These density differences result in motion. **(2.1b)**
- Seasonal changes can be explained using concepts of density and heat energy. These changes include the shifting of global temperature zones, the shifting of planetary wind and ocean current patterns, the occurrence of monsoons, hurricanes, flooding, and severe weather. **(2.1i)**
- The transfer of heat energy within the atmosphere, the hydrosphere, and Earth's surface occurs as the result of radiation, convection, and conduction. **(2.2b)**
  - Heating of Earth's surface and atmosphere by the Sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
- Feedback (negative or positive) can stabilize or destabilize a system.

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.
- Changes in systems may have various causes that may not have equal effects.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- 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.
- Energy drives the cycling of matter within and between systems.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

WHST.9-10.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.5: 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.

WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth.
- Guideline B—Changes in matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena.
- Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/EARTH SCIENCE THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf

[Refer to Appendix C – Reference Tables for Physical Setting/Earth Science]

Specific Heats of Common Materials (p1)

Properties of Water (p1)

Surface Ocean Currents (p4)

Electromagnetic Spectrum (p14)

ES | Unit 7 Meteorology

RECOMMENDED TIME: 17 DAYS

Unit Overview:

Earth may be considered a huge machine driven by two engines, one internal and one external. These heat engines convert heat energy into mechanical energy. Earth's external heat engine is powered primarily by solar energy and influenced by gravity. Nearly all the energy for circulating the atmosphere and oceans is supplied by the Sun. As insolation strikes the atmosphere, a small percentage is directly absorbed, especially by gases such as ozone, carbon dioxide, and water vapor. Clouds and Earth's surface reflect some energy back to space, and Earth's surface absorbs some energy. Energy is transferred between Earth's surface and the atmosphere by radiation, conduction, evaporation, and convection. Temperature variations within the atmosphere cause differences in density that cause atmospheric circulation, which is affected by Earth's rotation. The interaction of these processes results in the complex atmospheric occurrence known as weather. Precipitation resulting from the external heat engine's weather systems supplies moisture to Earth's surface that contributes to the weathering of rocks. Global climate is determined by the interaction of solar energy with Earth's surface and atmosphere. This energy transfer is influenced by dynamic processes such as cloud cover and Earth's rotation, and the positions of mountain ranges and oceans. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:

How can we predict the weather?

Key Ideas:

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
Major Understandings: *Quoted from the New York State Performance Indicators (1.2e, h; 2.1b-h; 2.2b, d)* ■ Earth's early atmosphere formed as a result of the outgassing of water vapor, carbon dioxide, nitrogen, and lesser amounts of other gases from its interior. **(1.2e)** *continued*	**Standard 2: Information Systems** **Key Idea 1:** Information technology is used to retrieve, process, and communicate information as a tool to enhance learning. **Key Idea 2:** Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use. *continued*	**Patterns:** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. ■ 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. ■ Empirical evidence is needed to identify patterns. *continued*

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

- The evolution of life caused dramatic changes in the composition of Earth’s atmosphere. Free oxygen did not form in the atmosphere until oxygen-producing organisms evolved. **(1.2h)**
- The transfer of heat energy within the atmosphere, the hydrosphere, and Earth’s interior results in the formation of regions of different densities. These density differences result in motion. **(2.1b)**
- Weather patterns become evident when weather variables are observed, measured, and recorded. These variables include air temperature, air pressure, moisture (relative humidity and dewpoint), precipitation (rain, snow, hail, sleet, etc.), wind speed and direction, and cloud cover. **(2.1c)**
- Air temperature, dewpoint, cloud formation, and precipitation are affected by the expansion and contraction of air due to vertical atmospheric movement. **(2.1f)**
- Weather variables can be represented in a variety of formats including radar and satellite images, weather maps (including station models, isobars, and fronts), atmospheric cross-sections, and computer models. **(2.1g)**
- Atmospheric moisture, temperature and pressure distributions; jet streams, wind; air masses and frontal boundaries; and the movement of cyclonic systems and associated tornadoes, thunderstorms, and hurricanes occur in observable patterns. Loss of property, personal injury, and loss of life can be reduced by effective emergency preparedness. **(2.1h)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Key Idea 3: Information technology can have positive and negative impacts on society, depending upon how it is used.

Standard 6: Interconnectedness: Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Standard 7: Interdisciplinary Problem Solving

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.
- Changes in systems may have various causes that may not have equal effects.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.
- 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.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf**		**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
■ The transfer of heat energy within the atmosphere, the hydrosphere, and Earth’s surface occurs as the result of radiation, convection, and conduction. **(2.2b)** 🍃 — Heating of Earth’s surface and atmosphere by the Sun drives convection within the atmosphere and oceans, producing winds and ocean currents. ■ Weather variables are interrelated. For example: **(2.1e)** 🍃 — temperature and humidity affect air pressure and probability of precipitation — air pressure gradient controls wind velocity ■ Weather variables are measured using instruments such as thermometers, barometers, psychrometers, precipitation gauges, anemometers, and wind vanes. **(2.1d)** ■ Temperature and precipitation patterns are altered by: **(2.2d)** 🍃 — natural events such as El Niño and volcanic eruptions — human influences including deforestation, urbanization, and the production of greenhouse gases such as carbon dioxide and methane		**Energy and Matter: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior. ■ 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. ■ Energy drives the cycling of matter within and between systems. **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. ■ Much of science deals with constructing explanations of how things change and how they remain stable. ■ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. ■ Feedback (negative or positive) can stabilize or destabilize a system.

COMMON CORE STATE STANDARDS **http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf** **http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf**	**ENVIRONMENTAL GUIDELINES FOR LEARNING** **http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf**	**TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/EARTH SCIENCE THAT ARE RELEVANT TO THE UNIT** **http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf**
ELA/Literacy **RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **WHST.9-10.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.9-10.5:** 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. **WHST.9-10.9:** Draw evidence from informational texts to support analysis, reflection, and research. **Mathematics** **HSN.Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN.Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN.Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	**Strand 2: Knowledge of Environmental Processes and Systems** **Strand 2.1: The Earth as a Physical System** ■ Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them. **Strand 3: Skills for Understanding and Addressing Environmental Issues** **Strand 3.2: Decision-Making and Citizenship Skills** ■ Guideline A—Forming and evaluating personal views—Learners are able to communicate, evaluate, and justify their own views on environmental issues and alternative ways to address them. ■ Guideline B—Evaluating the need for citizen action—Learners are able to decide whether action is needed in particular situations and whether they should be involved.	*[Refer to Appendix C – Reference Tables for Physical Setting/Earth Science]* Dewpoint (°C) (p12) Relative Humidity (%) (p12) Temperature (p13) Pressure (p13) Weather Map Symbols (p13) Selected Properties of Earth's Atmosphere (p14) Planetary Wind and Moisture Belts in the Troposphere (p14)

ES | Unit 8 Climate

RECOMMENDED TIME: 10 DAYS

Unit Overview:

Earth may be considered a huge machine driven by two engines, one internal and one external. These heat engines convert heat energy into mechanical energy. Earth's external heat engine is powered primarily by solar energy and influenced by gravity. Nearly all the energy for circulating the atmosphere and oceans is supplied by the Sun. As insolation strikes the atmosphere, a small percentage is directly absorbed, especially by gases such as ozone, carbon dioxide, and water vapor. Clouds and Earth's surface reflect some energy back to space, and Earth's surface absorbs some energy. Energy is transferred between Earth's surface and the atmosphere by radiation, conduction, evaporation, and convection. Temperature variations within the atmosphere cause differences in density that cause atmospheric circulation, which is affected by Earth's rotation. The interaction of these processes results in the complex atmospheric occurrence known as weather. Precipitation resulting from the external heat engine's weather systems supplies moisture to Earth's surface that contributes to the weathering of rocks. Global climate is determined by the interaction of solar energy with Earth's surface and atmosphere. This energy transfer is influenced by dynamic processes such as cloud cover and Earth's rotation, and the positions of mountain ranges and oceans. *[Refer to Appendix A for the Humane Treatment of Animals and Conservation Day]*

Essential Question:

Why are there different climates on Earth, and how can climate be altered?

Key Ideas:

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci/pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
Major Understandings: *Quoted from the New York State Performance Indicators (1.1a; 1.2b, g; 2.1i; o, r, s, 2.2b, c)* ■ Most objects in the solar system are in regular and predictable motion. **(1.1a)** — These motions explain such phenomena as the day, the year, seasons, phases of the moon, eclipses, and tides. *continued*	**Standard 2: Information Systems** **Key Idea 1:** Information technology is used to retrieve, process, and communicate information as a tool to enhance learning. **Key Idea 2:** Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use. *continued*	**Patterns:** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. ■ 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. ■ Empirical evidence is needed to identify patterns. *continued*

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

  - Gravity influences the motions of celestial objects. The force of gravity between two objects in the universe depends on their masses and the distance between them.
- Stars form when gravity causes clouds of molecules to contract until nuclear fusion of light elements into heavier ones occurs. Fusion releases great amounts of energy over millions of years. **(1.2b)**
  - The stars differ from each other in size, temperature, and age.
  - Our Sun is a medium-sized star within a spiral galaxy of stars known as the Milky Way. Our galaxy contains billions of stars, and the universe contains billions of such galaxies.
- Seasonal changes can be explained using concepts of density and heat energy. These changes include the shifting of global temperature zones, the shifting of planetary wind and ocean current patterns, the occurrence of monsoons, hurricanes, flooding, and severe weather. **(2.1i)**
- Plate motions have resulted in global changes in geography, climate, and the patterns of organic evolution. **(2.1o)**
- Climate variations, structure, and characteristics of bedrock influence the development of landscape features including mountains, plateaus, plains, valleys, ridges, escarpments, and stream drainage patterns. **(2.1r)**
- Weathering is the physical and chemical breakdown of rocks at or near Earth's surface. Soils are the result of weathering and biological activity over long periods of time. **(2.1s)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Key Idea 3: Information technology can have positive and negative impacts on society, depending upon how it is used.

Standard 6: Interconnectedness: Common Themes

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Key Idea 6: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

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NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf**		**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
■ The transfer of heat energy within the atmosphere, the hydrosphere, and Earth's surface occurs as the result of radiation, convection, and conduction. **(2.2b)** — Heating of Earth's surface and atmosphere by the Sun drives convection within the atmosphere and oceans, producing winds and ocean currents. ■ A location's climate is influenced by latitude, proximity to large bodies of water, ocean currents, prevailing winds, vegetative cover, elevation, and mountain ranges. **(2.2c)** ■ Earth has continuously been recycling water since the outgassing of water early in its history. This constant recirculation of water at and near Earth's surface is described by the hydrologic (water) cycle. **(1.2g)** — Water is returned from the atmosphere to Earth's surface by precipitation. Water returns to the atmosphere by evaporation or transpiration from plants. A portion of the precipitation becomes runoff over the land or infiltrates into the ground to become stored in the soil or groundwater below the water table. Soil capillarity influences these processes.		**Energy and Matter: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior. ■ 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. ■ Energy drives the cycling of matter within and between systems. **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. ■ Much of science deals with constructing explanations of how things change and how they remain stable. ■ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. ■ Feedback (negative or positive) can stabilize or destabilize a system.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

WHST.9-10.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-10.5: 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.

WHST.9-10.9: Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 1: Questioning, Analysis, and Interpretation Skills

- Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources.
- Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.

Strand 2.4: Environment And Society

- Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs.
- Guideline E—Environmental issues—Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that these scales and issues are often linked.

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/EARTH SCIENCE THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf

[Refer to Appendix C – Reference Tables for Physical Setting/Earth Science]

Specific Heats of Common Materials (p1)

Surface Ocean Currents (p4)

Selected Properties of Earth's Atmosphere (p14)

Planetary Wind and Moisture Belts in the Troposphere (p14)

Strand 3: Skills for Understanding and Addressing Environmental Issues

Strand 3.2: Decision-Making and Citizenship Skills

- Guideline A—Forming and evaluating personal views—Learners are able to communicate, evaluate, and justify their own views on environmental issues and alternative ways to address them.
- Guideline B—Evaluating the need for citizen action—Learners are able to decide whether action is needed in particular situations and whether they should be involved.
- Guideline D—Evaluating the results of actions—Learners are able to evaluate the effects of their own actions and actions taken by other individuals and groups, including possible intended and unintended consequences of actions.

ES | Unit 9 Astronomy

RECOMMENDED TIME: 17 DAYS

Unit Overview:

People have observed the stars for thousands of years, using them to find direction, note the passage of time, and to express their values and traditions. As our technology has progressed, so has understanding of celestial objects and events. Theories of the universe have developed over many centuries. Although to a casual observer celestial bodies appeared to orbit a stationary Earth, scientific discoveries led us to the understanding that Earth is one planet that orbits the Sun, a typical star in a vast and ancient universe. We now infer an origin and an age and evolution of the universe, as we speculate about its future. As we look at Earth, we find clues to its origin and how it has changed through nearly five billion years, as well as the evolution of life on Earth.

Essential Question:

How can celestial observations explain natural phenomena?

Key Ideas:

Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (1.1a, d, f, g, i; 1.2a, b)

- Earth rotates on an imaginary axis at a rate of 15 degrees per hour. To people on Earth, this turning of the planet makes it seem as though the Sun, the moon, and the stars are moving around Earth once a day. Rotation provides a basis for our system of local time; meridians of longitude are the basis for time zones. **(1.1d)**
- Earth's changing position with regard to the Sun and the moon has noticeable effects. **(1.1f)**
  - — Earth revolves around the Sun with its rotational axis tilted at 23.5 degrees to a line perpendicular to the plane of its orbit, with the North Pole aligned with Polaris.

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Standard 2: Information Systems

Students will access, generate, process, and transfer information using appropriate technologies.

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effective and ethical use.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- Patterns observable at one scale may not be observable or exist at other scales.
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

  - During Earth’s one-year period of revolution, the tilt of its axis results in changes in the angle of incidence of the Sun’s rays at a given latitude; these changes cause variation in the heating of the surface. This produces seasonal variation in weather.
- Approximately 70 percent of Earth’s surface is covered by a relatively thin layer of water, which responds to the gravitational attraction of the moon and the Sun with a daily cycle of high and low tides. **(1.1i)**
- Most objects in the solar system are in regular and predictable motion. **(1.1a)**
  - These motions explain such phenomena as the day, the year, seasons, phases of the moon, eclipses, and tides.
  - Gravity influences the motions of celestial objects. The force of gravity between two objects in the universe depends on their masses and the distance between them.
- Seasonal changes in the apparent positions of constellations provide evidence of Earth’s revolution. **(1.1g)**
- The universe is vast and estimated to be over ten billion years old. The current theory is that the universe was created from an explosion called the Big Bang. Evidence for this theory includes: **(1.2a)**
  - cosmic background radiation
  - a red-shift (the Doppler effect) in the light from very distant galaxies
- Stars form when gravity causes clouds of molecules to contract until nuclear fusion of light elements into heavier ones occurs. Fusion releases great amounts of energy over millions of years. **(1.2b)**
  - The stars differ from each other in size, temperature, and age.
  - Our Sun is a medium-sized star within a spiral galaxy of stars known as the Milky Way. Our galaxy contains billions of stars, and the universe contains billions of such galaxies.

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/earthsci.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 4: Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Standard 7: Interdisciplinary Problem Solving

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

COMMON CORE STATE STANDARDS **http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf** **http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf**	**ENVIRONMENTAL GUIDELINES FOR LEARNING** **http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf**	**TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/EARTH SCIENCE THAT ARE RELEVANT TO THE UNIT** **http://www.p12.nysed.gov/assessment/reftable/earthscience-rt/esrt2011-engr.pdf**
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CH

Chemistry

CH | Unit 1 The Physical Nature of Matter

RECOMMENDED TIME: 30 DAYS

Unit Overview:

Chemistry is the study of matter and energy explained and categorized using observable characteristics. All changes in matter are accompanied by changes in energy. Energy exists in many forms, and when these forms change, energy is conserved. Throughout history, humankind has tried to effectively use and convert various forms of energy. Energy is used to do work that makes life more productive and enjoyable. The Law of Conservation of Matter and Energy applies to phase changes, chemical changes, and nuclear changes, that help run our modern world. With a complete understanding of these processes and their application to the modern world comes a responsibility to take care of waste, limit pollution, and decrease potential risks.

Essential Question:

How can matter be explained in terms of stability and change?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Major Understandings:

Quoted from the New York State Performance Indicators 3.1dd, 3.1nn, 3.1q-u; 3.1jj; 3.1kk; 3.1oo; 3.1qq; 3.2a; 3.4a, b; 4.1a, b; 4.2a-c, 3.1pp

- Matter is classified as a pure substance or as a mixture of substances. **(3.1q)**
- A pure substance (element or compound) has a constant composition and constant properties throughout a given sample, and from sample to sample. **(3.1r)**
- Mixtures are composed of two or more different substances that can be separated by physical means. When different substances are mixed together, a homogeneous or heterogeneous mixture is formed. **(3.1s)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Examples include:

- use the Internet as a source to retrieve information for classroom use, e.g., Periodic Table, acid rain requiring improved investigations and experiments.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

- The proportions of components in a mixture can be varied. Each component in a mixture retains its original properties. **(3.1t)**
- Elements are substances that are composed of atoms that have the same atomic number. Elements cannot be broken down by chemical change. **(3.1u)**
- Compounds can be differentiated by their chemical and physical properties. **(3.1dd)**
- The structure and arrangement of particles and their interactions determine the physical state of a substance at a given temperature and pressure. **(3.1jj)**
- The three phases of matter (solids, liquids, gases) have different properties. **(3.1kk)**
- Differences in properties such as density, particle size, molecular polarity, boiling and freezing points, and solubility permit physical separation of the components of the mixture. **(3.1nn)**
- A solution is a homogeneous mixture of solute dissolved in a solvent. The solubility of a solute in a given amount of solvent is dependent on the temperature, the pressure, and the chemical natures of the solute and solvent. **(3.1oo)**
- The concentration of a solution may be expressed in molarity (M), percent by volume, percent by mass, or parts per million (ppm). **(3.1pp)**
- The addition of a nonvolatile solute to a solvent causes the boiling point of the solvent to increase and the freezing point of the solvent to decrease. The greater the concentration of the solute particles, the greater the effect. **(3.1qq)**
- A physical change results in the rearrangement of existing particles in a substance. A chemical change results in the formation of different substances with changed properties. **(3.2a)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Standard 7: Interdisciplinary Problem Solving

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

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- Changes in systems may have various causes that may not have equal effects.

Scale, Proportion, and Quantity

- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.
- 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).

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.
- 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.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

- The concept of an ideal gas is a model to explain the behavior of gases. A real gas is most like an ideal gas when the real gas is at low pressure and high temperature. **(3.4a)**
- Kinetic molecular theory (KMT) for an ideal gas states that all gas particles:
  - — are in random, constant, straight-line motion.
  - — are separated by great distances relative to their size; the volume of the gas particles is considered negligible.
  - — have no attractive force between them.
  - — have collisions that may result in a transfer of energy between gas particles, but the total energy of the system remains constant. **(3.4b)**
- Energy can exist in different forms, such as chemical, electrical, electromagnetic, thermal, mechanical, nuclear. **(4.1a)** 🍃
- Chemical and physical changes can be exothermic or endothermic. **(4.1b)** 🍃
- Heat is a transfer of energy (usually thermal energy) from a body of higher temperature to a body of lower temperature. Thermal energy is the energy associated with the random motion of atoms and molecules. **(4.2a)** 🍃
- Temperature is a measurement of the average kinetic energy of the particles in a sample of material. Temperature is not a form of energy. **(4.2b)**
- The concepts of kinetic and potential energy can be used to explain physical processes that include: fusion (melting), solidification (freezing), vaporization (boiling, evaporation), condensation, sublimation, and deposition. **(4.2c)** 🍃

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.

Cause and Effect: Mechanism and Prediction:

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.
- Changes in systems may have various causes that may not have equal effects.

Energy and Matter: Flows, Cycles, and Conservation:

- The total amount of energy and matter in closed systems 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.
- Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems.

Structure and Function: The way an object is shaped or structured determines many of its properties and functions.

- 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.
- 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.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/Math/
http://www.corestandards.org/ELA-Literacy/

ELA/Literacy

RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

WHST.9–12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

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.

WHST.9–12.9: Draw evidence from informational texts to support analysis, reflection, and research.

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.

Mathematics

MP.2: Reason abstractly and quantitatively.

MP.4: Model with mathematics.

HSN-Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

- Guideline B—Changes in Matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena.
- Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/ CHEMISTRY THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/chemistry-rt/chemrt-2011.pdf

[Refer to Appendix B – Reference Tables for Physical Setting/Chemistry]

Table A – Standard Temperature and Pressure

Table B – Physical Constants for Water

Table C – Selected Prefixes

Table D – Selected Units

The Periodic Table of Elements

Table S – Properties of Selected Elements

Table T – Important Formulas and Equations

CH | Unit 2 Atomic Concepts

RECOMMENDED TIME: 20 DAYS

Unit Overview:

Through decades of experimentation and modeling that began in the late 1800s, it was determined that matter was composed of particles called atoms. An atom has a small, dense nucleus in the center with electrons moving about in the empty space surrounding the nucleus. Energy was thought to exist in small, indivisible packets called quanta, and this theory was used to develop a model of the atom which had a central nucleus surrounded by shells of electrons. The model was used to explain the properties of chemical bonding, and additional experimentation with radioactivity provided evidence that atomic nuclei contained protons and neutrons. Changes in motion result from the interaction of matter and energy.

Essential Question:

How is the structure of an atom like other systems models?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Major Understandings:

Quoted from the New York State Performance Indicators 3.1a-f, h-n; 5.2c

- The modern model of the atom has evolved over a long period of time through the work of many scientists. **(3.1a)**
- Each atom has a nucleus, with an overall positive charge, surrounded by negatively charged electrons. **(3.1b)**
- Subatomic particles contained in the nucleus include protons and neutrons. **(3.1c)**
- The proton is positively charged, and the neutron has no charge. The electron is negatively charged. **(3.1d)**
- Protons and electrons have equal but opposite charges. The number of protons equals the number of electrons in an atom. **(3.1e)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Examples include:

- Use the Internet as a source to retrieve information for classroom use, e.g., research history of atomic structures and scientific development of modern atomic theory.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments.
- Empirical evidence is needed to identify patterns.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

- The mass of each proton and each neutron is approximately equal to one atomic mass unit. An electron is much less massive than a proton or a neutron. **(3.1f)**
- In the wave-mechanical model (electron cloud model) the electrons are in orbitals, which are defined as the regions of the most probable electron location (ground state). **(3.1h)**
- Each electron in an atom has its own distinct amount of energy. **(3.1i)**
- When an electron in an atom gains a specific amount of energy, the electron is at a higher energy state (excited state). **(3.1j)**
- When an electron returns from a higher energy state to a lower energy state, a specific amount of energy is emitted. This emitted energy can be used to identify an element. **(3.1k)**
- The outermost electrons in an atom are called the valence electrons. In general, the number of valence electrons affects the chemical properties of an element. **(3.1l)**
- Atoms of an element that contain the same number of protons but a different number of neutrons are called isotopes of that element. **(3.1m)**
- The average atomic mass of an element is the weighted average of the masses of its naturally occurring isotopes. **(3.1n)**
- When an atom gains one or more electrons, it becomes a negative ion and its radius increases. When an atom loses one or more electrons, it becomes a positive ion and its radius decreases. **(5.2c)**

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- 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.
- Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems.

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- 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.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.
- 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.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/Math/
http://www.corestandards.org/ELA-Literacy/

ELA/Literacy

RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

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Mathematics

MP.2: Reason abstractly and quantitatively.

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HSN-Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

- Guideline B—Changes in Matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena.
- Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/ CHEMISTRY THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/chemistry-rt/chemrt-2011.pdf

[Refer to Appendix B – Reference Tables for Physical Setting/Chemistry]

Table C – Selected Prefixes

Table D – Selected Units

Table O – Symbols Used in Nuclear Chemistry

The Periodic Table of Elements

Table S – Properties of Selected Elements

CH | Unit 3 Nuclear Chemistry

RECOMMENDED TIME: 20 DAYS

Unit Overview:

The discovery of the energy stored in the nucleus of an atom, its uses, and its benefits and risks is a continuing process that began with the detection of the first radioactive isotope. Using radioactivity, the inner structure of the atom was defined by other researchers. Scientists involved in the development of nuclear fission and the atomic bomb explored both peaceful and destructive uses of nuclear energy. Modern researchers continue to search for ways in which the power of the nucleus can be used for the betterment of the world. With a complete understanding of these processes and their application to the modern world comes a responsibility to take care of waste, limit pollution, and decrease potential risks.

Essential Questions:

Why is this alternative energy source so controversial?

Is this really an alternative energy source?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Major Understandings:

Quoted from the New York State Performance Indicators 3.1m-p; 4.1a, 4.4a-f; 5.3a-c

- Atoms of an element that contain the same number of protons but a different number of neutrons are called isotopes of that element. **(3.1m)**
- The average atomic mass of an element is the weighted average of the masses of its naturally occurring isotopes. **(3.1n)**
- Stability of an isotope is based on the ratio of the neutrons and protons in the nucleus. Although most nuclei are stable, some are unstable and spontaneously decay, emitting radiation. **(3.1o)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Key Idea 2: Knowledge of the impacts and limitations of information systems is essential to its effectiveness and ethical use.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

- Spontaneous decay can involve the release of alpha particles, beta particles, positrons and/or gamma radiation from the nucleus of the unstable isotope. These emissions differ in mass, charge, ionizing power and penetrating power. **(3.1p)**
- Energy can exist in different forms, such as chemical, electric, electromagnetic, thermal, mechanical, nuclear. **(4.1a)**
- Each radioactive isotope has a specific mode and rate of decay (half-life). **(4.4a)**
- Nuclear reactions include natural and artificial transmutation, fission and fusion. **(4.4b)**
- Nuclear reactions can be represented by equations that include symbols which represent atomic nuclei (with mass number and atomic number), subatomic particles (with mass number and charge), and/or emissions such as gamma radiation. **(4.4c)**
- Radioactive isotopes have many beneficial uses. Radioactive isotopes are used in medicine and industrial chemistry for radioactive dating, tracing chemical and biological processes, industrial measurement, nuclear power and detection and treatment of diseases. **(4.4d)**
- There are inherent risks associated with radioactivity and the use of radioactive isotopes. Risks can include biological exposure, long-term storage and disposal, and nuclear accidents. **(4.4e)**
- There are benefits and risks associated with fission and fusion reactions. **(4.4f)**
- A change in the nucleus of an atom that converts it from one element to another is called transmutation. This can occur naturally or can be induced by the bombardment of the nucleus with high-energy particles. **(5.3a)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/next-generation-science-standards

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- 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).

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- The total amount of energy and matter in closed systems 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.
- Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems.
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf**		**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
■ Energy released in a nuclear reaction (fission or fusion) comes from the fractional amount of mass that is converted into energy. Nuclear changes convert matter into energy. **(5.3b)** 🍃 ■ Energy released during nuclear reactions is much greater than the energy released during chemical reactions. **(5.3c)** 🍃		**Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ■ 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. **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. ■ Much of science deals with constructing explanations of how things change and how they remain stable. ■ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

COMMON CORE STATE STANDARDS http://www.corestandards.org/Math/ http://www.corestandards.org/ELA-Literacy/	ENVIRONMENTAL GUIDELINES FOR LEARNING http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf	TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/ CHEMISTRY THAT ARE RELEVANT TO THE UNIT http://www.p12.nysed.gov/assessment/reftable/chemistry-rt/chemrt-2011.pdf
ELA/Literacy **RST.9-10.7:** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **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. **Mathematics** **MP.4:** Model with mathematics. **HSN-Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	**Strand 2: Knowledge of Environmental Processes and Systems** ▪ Guideline B—Changes in Matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena. ▪ Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.	*[Refer to Appendix B – Reference Tables for Physical Setting/Chemistry]* Table C – Selected Prefixes Table D – Selected Units Table N – Selected Radioisotopes Table O – Symbols Used in Nuclear Chemistry The Periodic Table of Elements Table S – Properties of Selected Elements

CH Unit 4 Chemical Bonding

RECOMMENDED TIME: 20 DAYS

Unit Overview:

The concept of a chemical bond is the core principle behind most of chemistry. Bonding is what enables atoms of elements to join in multiple combinations to form more than fifty million chemical substances in our world. There are several types of chemical bonds with specific characteristics that require unique circumstances to account for the various chemical combinations we find on earth.

Essential Question:

Why do some atoms form chemical bonds to form stable compounds and others do not?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Major Understandings:

Quoted from the New York State Performance Indicators 5.2a-e, 5.2g-n, 3.1cc, 3.1ee, 3.1oo, 3.1pp, 3.1qq, 3.2b, 3.3a, c, e

- Chemical bonds are formed when valence electrons are:
  - transferred from one atom to another (ionic)
  - shared between atoms (covalent)
  - mobile within a metal (metallic) **(5.2a)**
- Atoms attain a stable valence electron configuration by bonding with other atoms. Noble gases have stable valence configurations and tend not to bond. **(5.2b)**
- When an atom gains one or more electrons, it becomes a negative ion and its radius increases. When an atom loses one or more electrons, it becomes a positive ion and its radius decreases. **(5.2c)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

- Electron-dot diagrams (Lewis structures) can represent the valence electron arrangement in elements, compounds, and ions. **(5.2d)**
- In a multiple covalent bond, more than one pair of electrons is shared between two atoms. Unsaturated organic compounds contain at least one double or triple bond. **(5.2e)**
- Two major categories of compounds are ionic and molecular (covalent) compounds. **(5.2g)**
- Metals tend to react with nonmetals to form ionic compounds. Nonmetals tend to react with other nonmetals to form molecular (covalent) compounds. Ionic compounds containing polyatomic ions have both ionic and covalent bonding. **(5.2h)**
- When a bond is broken, energy is absorbed. When a bond is formed, energy is released. **(5.2i)**
- Electronegativity indicates how strongly an atom of an element attracts electrons in chemical bonds. Electronegativity values are assigned according to arbitrary scales. **(5.2j)**
- The electronegativity difference between two bonded atoms is used to assess the degree of polarity in the bond. **(5.2k)**
- Molecular polarity can be determined by the shape of the molecule and distribution of charge. Symmetrical (nonpolar) molecules include CO_2, CH_4, and diatomic elements. Asymmetrical (polar) molecules include HCl, NH_3, and H_2O. **(5.2l)**
- Intermolecular forces created by the unequal distribution of charge result in varying degrees of attraction between molecules. Hydrogen bonding is an example of a strong intermolecular force. **(5.2m)**
- Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point and boiling point. **(5.2n)**
- A compound is a substance composed of two or more different elements that are chemically combined in a fixed proportion. A chemical compound can be broken down by chemical means. A chemical compound can be represented by a specific chemical formula and assigned a name based on the IUPAC system. **(3.1cc)**
- Types of chemical formulas include empirical, molecular, and structural. **(3.1ee)**
- A solution is a homogeneous mixture of solute and solvent. The solubility of a solute in a given amount of solvent is dependent on the temperature, the pressure, and the chemical natures of the solute and solvent. **(3.1oo)**
- The concentration of a solution may be expressed in molarity (M), percent by volume, percent by mass, or parts per million (ppm). **(3.1pp)**
- The addition of a nonvolatile solute to a solvent causes the boiling point of the solvent to increase and the freezing point of the solvent to decrease. The greater the concentration of solute particles, the greater the effect. **(3.1qq)**
- The types of chemical reactions include synthesis, decomposition, single replacement, and double replacement. **(3.2b)**
- In all chemical reaction there is a conservation of mass, energy and charge. **(3.3a)**

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.

Energy and Matter: Flows Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.

- The total amount of energy and matter in closed systems 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.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
■ A balanced chemical equation represents conservation of atoms. The coefficients in a balanced chemical equation can be used to determine mole ratios in the reaction. **(3.3c)** ■ The formula mass of a substance is a sum of the atomic masses. The molar mass (gram-formula mass) of a substance equals one mole of that substance. **(3.3e)**	■ Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems. ■ Energy drives the cycling of matter within and between systems. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ■ 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. **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. ■ Much of science deals with constructing explanations of how things change and how they remain stable. ■ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

COMMON CORE STATE STANDARDS **http://www.corestandards.org/Math/** **http://www.corestandards.org/ELA-Literacy/**	**ENVIRONMENTAL GUIDELINES FOR LEARNING** **http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf**	**TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/ CHEMISTRY THAT ARE RELEVANT TO THE UNIT** **http://www.p12.nysed.gov/assessment/reftable/chemistry-rt/chemrt-2011.pdf**
ELA/Literacy **WHST.9–12.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **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. **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. **Mathematics** **MP.2:** Reason abstractly and quantitatively. **MP.4:** Model with mathematics. **HSN-Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	**Strand 1: Questioning, Analysis and Interpretation Skills** ▪ Guideline E—Organizing Information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes. ▪ Guideline F—Working with Models and Simulations — Learners are able to create, use, and evaluate models to understand environmental phenomena	*[Refer to Appendix B – Reference Tables for Physical Setting/Chemistry]* Table E – Selected Polyatomic Ions Table F – Solubility Guidelines for Aqueous Solutions The Periodic Table of Elements Table S – Properties of Selected Elements

CH | Unit 5 Periodicity

RECOMMENDED TIME: 5 DAYS

Unit Overview:

The element phosphorous was isolated and “discovered” in the late 1600s, but it was not until the mid-1800s that a serious attempt at organizing the arrangement of elements was made by a Russian chemist named Dimitri Mendeleev. In his development of the periodic table, Mendeleev became aware of repeating patterns and knew that there were elements that had yet to be discovered and so left open spaces in the Periodic Table of elements to accommodate for future discoveries. Through meticulous investigations and careful organization, the Periodic Table of Elements is a wealth of chemical information.

Essential Questions:

What are the trends in the Periodic Table of Elements as you go from left to right and top to bottom?

What are the factors that determine each of the trends you see?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Major Understandings:

Quoted from the New York State Performance Indicators 3.1y, 3.1aa, 3.1bb, 3.1g, l, 3.1v-z, 5.2b, f, h

- The placement or location of an element on the Periodic Table gives an indication of the physical and chemical properties of the element. The elements on the Periodic Table are arranged in order of increasing atomic number. **(3.1y)**
- The succession of elements within the same group demonstrates characteristic trends: differences in atomic radius, ionic radius, electronegativity, first ionization energy, metallic/non-metallic properties. **(3.1aa)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Mathematical representations are needed to identify some patterns.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

- The succession of elements across the same period demonstrates characteristic trends: differences in atomic radius, ionic radius, electronegativity, first ionization energy, metallic/nonmetallic properties. **(3.1bb)**
- The number of protons in an atom (atomic number) identifies the element. The sum of the protons and neutrons in an atom (mass number) identifies the isotope. Common notations that represent isotopes include: ^{14}C, $^{14}_{6}C$, carbon-14, C-14. **(3.1g)**
- The outermost electrons in an atom are called the valence electrons. In general, the number of valence electrons affects the chemical properties of an element. **(3.1l)**
- Elements can be classified by their properties and are located on the Periodic Table as metals, non-metals, metalloids (B, Si, Ge, As, Sb, Te) and noble gases. **(3.1v)**
- Elements can be differentiated by physical properties. Physical properties of substances, such as density, conductivity, malleability, solubility and hardness differ among elements. **(3.1w)** 🍃
- Elements can also be differentiated by chemical properties. Chemical properties describe how an element behaves during a chemical reaction. **(3.1x)** 🍃
- The placement or location of an element on the Periodic Table gives an indication of the physical and chemical properties of that element. The elements on the Periodic Table are arranged in order of increasing atomic number. **(3.1y)** 🍃
- For Groups 1, 2, 13–18 on the Periodic Table, elements with the same group have the same number of valence electrons (helium is the exception) and therefore similar chemical properties. **(3.1z)**
- Atoms attain a stable valence electron configuration by bonding with other atoms. Nobel gases have stable valence configurations and tend not to bond. **(5.2b)**
- Some elements exist in two or more forms in the same phase. These forms differ in their molecular or crystal structure, and hence their properties. **(5.2f)** 🍃
- Metals tend to react with nonmetals to form ionic compounds. Nonmetals tend to react with nonmetals to form molecular (covalent) compounds. Ionic compounds containing polyatomic ions have both ionic and covalent bonding. **(5.2h)** 🍃

NGSS CROSS-CUTTING CONCEPTS

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- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- 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.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Systems can be designed for greater or lesser stability.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/Math/
http://www.corestandards.org/ELA-Literacy/

ELA/Literacy

RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

WHST.9–12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

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.

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.

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

WHST.9–12.9: Draw evidence from informational texts to support analysis, reflection, and research.

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.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 1: Questioning, Analysis, and Interpretation Skills

- Guideline E—Organizing Information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes.
- Guideline F—Working with Models and Simulations—Learners are able to create, use and evaluate models to understand environmental phenomena.

Mathematics

MP.2: Reason abstractly and quantitatively.

MP.4: Model with mathematics.

HSN-Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/ CHEMISTRY THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/chemistry-rt/chemrt-2011.pdf

[Refer to Appendix B – Reference Tables for Physical Setting/Chemistry]

The Periodic Table of Elements

Table S – Properties of Selected Elements

CH | Unit 6 Moles/Stoichiometry

RECOMMENDED TIME: 12 DAYS

Unit Overview:

Stoichiometry is the term used for the calculation of a balanced chemical reaction. As per the Law of Conservation of Matter, the number and type of atoms that go into a reaction must match the number and type of atoms that are formed as the product of the reaction. This means that if the amounts of the separate reactants are known, then the amount of the product can be calculated. As with algebra, once this is known, the variable can be determined. A mole is a unit of measurement in chemistry expressed as Avogadro's constant (6.02×10^{23}) and equal to a substance's mean molecular mass.

Essential Questions:

What is the purpose of knowing the amounts of substances involved in chemical equations?

How can this knowledge inform the work of chemical engineers?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Major Understandings:

Quoted from the New York State Performance Indicators 3.1cc, 3.1ee, 3.1n, 3.3a, c-f, 3.4e, 3.1oo, 3.1pp, 3.1qq, 3.2b

- A compound is a substance composed of two or more different elements that are chemically combined in fixed proportions. A chemical compound can be broken down by chemical means. A chemical compound can be represented by a specific chemical formula and assigned a name based on the IUPAC (International Union of Pure and Applied Chemistry — http://www.iupac.org/) System **(3.1cc)**
- Types of chemical formulas include empirical, molecular, and structural. **(3.1ee)**
- The average atomic mass of an element is the weighted average of the masses of its naturally occurring isotopes. **(3.1n)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

- The formula mass of a substance is the sum of the atomic masses of its atoms. The molar mass (gram-formula mass) of a substance equals one mole of that substance. **(3.3e)**
- Equal volumes of gases at the same temperature and pressure contain an equal number of particles. **(3.4e)**
- The empirical formula of a compound is the simplest whole-number ratio of the atoms of elements in the compound. It may be different from the molecular formula, which is the actual ratio of atoms in a molecule of that compound. **(3.3d)**
- A balanced chemical equation represents conservation of atoms. The coefficients in a balanced chemical equation can be used to determine mole ratios in the reaction. **(3.3c)**
- In all chemical reactions, there is a conservation of mass, energy and charge. **(3.3a)**
- A solution is a homogeneous mixture of solute dissolved in solvent. The solubility of the solute in a given amount of solvent is dependent on the temperature, the pressure, and the chemical natures of the solute and the solvent. **(3.1oo)**
- The concentration of the solution may be expressed in molarity (M), percent by volume, percent by mass or parts per million (ppm). **(3.1pp)**
- The addition of a nonvolatile solute to a solvent causes the boiling point of the solvent to increase and the freezing point of the solvent to decrease. The greater the concentration of solute, the greater the effect. **(3.1qq)**
- The percent composition by mass of each element in a compound can be calculated mathematically. **(3.3f)**
- Types of chemical reaction include synthesis, decomposition, single replacement, and double replacement. **(3.2b)**

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

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

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- The total amount of energy and matter in closed systems 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.
- Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems.
- Energy drives the cycling of matter within and between systems.

Structure and Function:

The way an object is shaped or structured determines many of its properties and functions.

- 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.
- 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.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
- Systems can be designed for greater or lesser stability.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/Math/
http://www.corestandards.org/ELA-Literacy/

ELA/Literacy

WHST.9–12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

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.

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.

Mathematics

MP.2: Reason abstractly and quantitatively.

MP.4: Model with mathematics.

HSN-Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2: Knowledge of Environmental Processes and Systems

- Guideline B—Changes in Matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena.
- Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/ CHEMISTRY THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/chemistry-rt/chemrt-2011.pdf

[Refer to Appendix B – Reference Tables for Physical Setting/Chemistry]

Table A – Standard Temperature and Pressure

Table B – Physical Constants for Water

Table C – Selected Prefixes

Table D – Selected Units

Table E – Selected Polyatomic Ions

Table F – Solubility Guidelines for Aqueous Solutions

Table G – Solubility Curves at Standard Temperature and Pressure

Table I – Heats of Reaction at 101.3 kPA and 29K

The Periodic Table of Elements

Table S – Properties of Selected Elements

Table T – Important Formulas and Equations

CH | Unit 7 Kinetics & Equilibrium

RECOMMENDED TIME: 15 DAYS

Unit Overview:

Chemical equilibrium is the state of constant composition attained when opposing reaction rates become equal in a closed system. In other words, the reactants and the products do not have to necessarily be equal, but the rate at which they are formed is equal. Kinetics is the term for particles in motion, and the movement of these particles will be determined by the forces or stresses that are added or removed from a system. Chemical reactions happen when particles with adequate energy and proper orientation collide. This process may absorb or release energy and can be represented visually using a graph of potential energy.

Essential Questions:

How is the equilibrium of a chemical system the same as homeostasis in living things?

A balance of vectors in engineering?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Major Understandings:

Quoted from the New York State Performance Indicators 3.4a-d, f-j; 4.1c, d; 3.11ll, 3.1mm; 4.2 b, c

- Collision theory states that a reaction is most likely to occur if reactant particles collide with proper energy and orientation. **(3.4d)**
- The rate of a chemical reaction depends on several factors: temperature, concentration, nature of the reactants, surface area, and the presence of a catalyst. **(3.4f)**
- The concept of an ideal gas is a model to explain the behavior of gases. A real gas is most like an ideal gas when the gas is at low pressure and high temperature. **(3.4a)**
  - — Kinetic molecular theory (KMT) for an ideal gas states that all gas particles:

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

continued

NGSS CROSS-CUTTING CONCEPTS

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Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.

continued

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– are in random, constant straight-line motion. – are separated by great distances relative to their size; the volume of the gas particles is considered negligible. – have no attractive forces between them. – have collisions that may result in a transfer of energy between gas particles, but the total energy of the system remains constant. **(3.4b)** ▪ Kinetic molecular theory describes the relationships of pressure, volume, temperature, velocity, and frequency and force of collision among gas particles. **(3.4c)** ▪ A catalyst provides an alternative reaction pathway, which has a lower activation energy than an uncatalyzed reaction. **(3.4g)** ▪ Some chemical and physical changes can reach equilibrium. **(3.4h)** ▪ At equilibrium the rate of the forward reaction equals the rate of the reverse reaction. The measureable quantities of reactants and products remain constant at equilibrium. **(3.4i)** ▪ Le Chatelier's principle can be used to predict the effect of stress (change in pressure, volume, concentration, and temperature) on a system at equilibrium. **(3.4j)** ▪ Energy released or absorberd during a chemical reaction can be represented by a potential energy diagram. **(4.1c)** ▪ Energy released or absorbed during a chemical reaction (heat of reaction) is equal to the difference between the potential energy of the products and the potential energy of the reactants. **(4.1d)** ▪ Temperature is the measurement of the average kinetic energy of the particles in a sample of material and not a form of energy. **(4.2b)** *continued*	**Key Idea 3:** The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. **Key Idea 4:** Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium). **Key Idea 5:** Identifying patterns of change is necessary for making predictions about future behavior and conditions.	**Cause and Effect: Mechanism and Prediction:** Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. ▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ▪ Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ▪ Changes in systems may have various causes that may not have equal effects. **Scale, Proportion, and Quantity:** In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change. ▪ The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ▪ Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. ▪ Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. ▪ 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). *continued*

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**	
■ The concept of kinetic and potential energy can be used to explain physical processes that include: fusion (melting), solidification (freezing), vaporization (boiling, evaporation), condensation, sublimation, and deposition. **(4.2c)** 🍃 ■ Entropy is a measure of the randomness or disorder of a system. A system with greater disorder has greater entropy. **(3.1ll)** ■ Systems in nature tend to undergo changes toward lower energy and higher entropy. **(3.1mm)** 🍃	**Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ■ 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. **Energy and Matter: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior. ■ The total amount of energy and matter in closed systems 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. ■ Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems.	**Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. ■ Much of science deals with constructing explanations of how things change and how they remain stable. ■ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. ■ Feedback (negative or positive) can stabilize or destabilize a system. ■ Systems can be designed for greater or lesser stability.

COMMON CORE STATE STANDARDS **http://www.corestandards.org/Math/** **http://www.corestandards.org/ELA-Literacy/**	**ENVIRONMENTAL GUIDELINES FOR LEARNING** **http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf**	**TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/ CHEMISTRY THAT ARE RELEVANT TO THE UNIT** **http://www.p12.nysed.gov/assessment/reftable/chemistry-rt/chemrt-2011.pdf**
ELA/Literacy **RST.9-10.7:** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **WHST.9–12.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.9–12.9:** Draw evidence from informational texts to support analysis, reflection, and research. **Mathematics** **MP.2:** Reason abstractly and quantitatively. **HSN-Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	**Strand 2: Knowledge of Environmental Processes and Systems** ▪ Guideline B—Changes in Matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena. ▪ Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.	*[Refer to Appendix B – Reference Tables for Physical Setting/Chemistry]* Table A – Standard Temperature and Pressure Table G – Solubility Curves at Standard Temperature and Pressure Table H – Vapor Pressure of Four Liquids Table I – Heats of Reaction at 101.3kPa and 298K The Periodic Table of Elements Table S – Properties of Selected Elements Table T – Important Formulas and Equations

CH | Unit 8 Acids & Bases

RECOMMENDED TIME: 15 DAYS

Unit Overview:

Understanding acids and bases is important for grasping chemistry concepts. Simple double-replacement reactions can make the difference between solutions that can cause great harm and those that are relatively benign. The uses for both acids and bases are seemingly endless and a major topic of study in the general chemistry course.

Essential Questions:

What are the essential components of both acids and bases that make them similar? Different?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Major Understandings:

Quoted from New York State Performance Indicators 3.1rr-zz, 5.2n, 3.2b

- An electrolyte is a substance which, when dissolved in water, forms a solution capable of conducting an electric current. The ability of a solution to conduct an electric current depends on the concentration of ions. **(3.1rr)**
- Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point, and boiling point. **(5.2n)**
- The acidity or alkalinity of an aqueous solution can be measured by its pH value. The relative level of acidity or alkalinity of these solutions can be shown by using indicators. **(3.1ss)**
- On the pH scale, each decrease of one unit of pH represents a tenfold increase in hydronium ion concentration. **(3.1tt)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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 of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.
- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.

Cause and Effect: Mechanism and Prediction:

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which t hey are mediated, is a major activity of science and engineering.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

- Behavior of many acids and bases can be explained by the Arrhenius theory. Arrhenius acids and bases are electrolytes. **(3.1uu)**
- Arrhenius acids yield H^+(aq), hydrogen ion as the only positive ion in an aqueous solution. The hydrogen ion may also be written as H_3O^+(aq), hydronium ion. **(3.1vv)**
- Arrhenius bases yield OH^-(aq), hydroxide ion as the only negative ion in an aqueous solution. **(3.1ww)**
- In the process of neutralization, an Arrhenius acid and an Arrhenius base react to form a salt and water. **(3.1xx)**
- There are alternate acid-base theories. One theory states that an acid is an H^+ donor and a base is an H^+ acceptor. **(3.1yy)**
- Titration is a laboratory process in which a volume of a solution of known concentration is used to determine the concentration of another solution. **(3.1zz)**
- Types of chemical reactions include synthesis, decomposition, single replacement, and double replacement. **(3.2b)**

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

If students are asked to do a project, then the project would require students to:

- Work effectively
- Gather and process information
- Generate and analyze ideas
- Observe common themes
- Realize ideas
- Present results

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/next-generation-science-standards

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.
- Systems can be designed to cause a desired effect.
- Changes in systems may have various causes that may not have equal effects.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change

- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- 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).

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems can be designed to do specific tasks.
- 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.

continue

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

- 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.

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- The total amount of energy and matter in closed systems 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.
- Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems.
- Energy drives the cycling of matter within and between systems.

Stability and Change:

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
- Feedback (negative or positive) can stabilize or destabilize a system.
- Systems can be designed for greater or lesser stability.

COMMON CORE STATE STANDARDS http://www.corestandards.org/Math/ http://www.corestandards.org/ELA-Literacy/	**ENVIRONMENTAL GUIDELINES FOR LEARNING** http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf	**TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/ CHEMISTRY THAT ARE RELEVANT TO THE UNIT** http://www.p12.nysed.gov/assessment/reftable/chemistry-rt/chemrt-2011.pdf
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CH | Unit 9 Oxidation & Reduction

RECOMMENDED TIME: 15 DAYS

Unit Overview:

Redox is a term that is used to describe any and all chemical reactions in which the oxidation state of the atoms in the reaction changes. Reduction is the gaining of these electrons, and oxidation is the loss of the electrons. These half- reactions involving the transfer of electrons from one to another occur simultaneously.

Essential Question:

How can we make electrochemistry work for us?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Major Understandings:

Quoted from New York State Performance Indicators 3.1b, 3.2d-l, 3.3a, b

- Each atom has a nucleus, with an overall positive charge, surrounded by negatively charged electrons. **(3.1b)**
- An oxidation-reduction (redox) reaction involves the transfer of electrons (e-). **(3.2d)** 🍃
- Reduction is the gain of electrons. **(3.2e)** 🍃
- A half-reaction can be written to represent reduction. **(3.2f)**
- Oxidation is the loss of electrons. **(3.2g)** 🍃
- A half-reaction can be written to represent oxidation. **(3.2h)**
- In a redox reaction the number of electrons lost is equal to the number of electrons gained. **(3.3b)** 🍃
- Oxidation numbers (states) can be assigned to atoms and ions. Changes in oxidation numbers indicate that oxidation and reduction have occurred. **(3.2i)**
- In all chemical reactions there is a conservation of mass, energy, and charge. **(3.3a)** 🍃
- Each electron in an atom has its own distinct amount of energy. **(3.1i)** 🍃
- An electrochemical cell can be either voltaic or electrolytic. In an electrochemical cell, oxidation occurs at the anode and reduction at the cathode. **(3.2j)**
- A voltaic cell spontaneously converts chemical energy to electrical energy. **(3.2k)** 🍃
- An electrolytic cell requires electrical energy to produce a chemical change. This process is known as electrolysis. **(3.2l)** 🍃

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 6: Interconnectedness: Common Themes—Equilibrium and Stability

Key Idea 4: Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Energy and Matter

- The total amount of energy and matter in closed systems 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.

Stability and Change

Much of science deals with constructing explanations of how things change and how they remain stable.

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ELA/Literacy **RST.9-10.7:** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **WHST.9–12.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.9–12.9:** Draw evidence from informational texts to support analysis, reflection, and research. **Mathematics** **MP.2:** Reason abstractly and quantitatively. **MP.4:** Model with mathematics. **HSN-Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	**Strand 2: Knowledge of Environmental Processes and Systems** ▪ Guideline B—Changes in Matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena. ▪ Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.	*[Refer to Appendix B – Reference Tables for Physical Setting/Chemistry]* Table E – Selected Polyatomic Ions Table O – Symbols Used in Nuclear Chemistry The Periodic Table of Elements Table S – Properties of Selected Elements

CH | Unit 10 Carbon and Organic Chemistry

RECOMMENDED TIME: 13 DAYS

Unit Overview:

Organic compounds always contain carbon and are the basis of all living things. The chemical structure of carbon includes four valence electrons, which allows for a multitude different structures. Naturally occurring carbon compounds include carbohydrates, lipids, proteins, and nucleic acids. Synthetic carbon-based compounds include credit cards, disposable diapers, spandex clothing, and many parts of automobiles.

Essential Questions:

What are the changes that have occurred in the last 50 years due to the increased use of carbon-based products?

Do the benefits outweigh the environmental risks?

Key Ideas:

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Major Understandings:

Quoted from the New York State Performance Indicators: 3.1ff-ii, 3.1jj, 3.1n, 5.2e, 3.2c

- Organic compounds contain carbon atoms, which bond to one another in chains, rings, and networks to form a variety of structures. Organic compounds can be named using the IUPAC (International Union of Pure and Applied Chemistry – http://www.iupac.org) System. **(3.1ff)**
- Hydrocarbons are compounds that contain only carbon and hydrogen. Saturated hydrocarbons contain only single carbon-carbon bonds. Unsaturated hydrocarbons contain at least one multiple carbon-carbon bond. **(3.1gg)**
- Organic acids, alcohols, esters, aldehydes, ketones, ethers, halides, amines, amides, and amino acids are categories of organic compounds that differ in their structures. Functional groups impart distinctive physical and chemical properties to organic compounds. **(3.1hh)**
- Isomers of organic compounds have the same molecular formula, but different structures and properties. **(3.1ii)**
- In a multiple covalent bond, more than one pair of electrons is shared between two atoms. Unsaturated organic compounds contain at least one double or triple bond. **(5.2e)**
- Types of organic reactions include: addition, substitution, polymerization, esterification, fermentation, saponification, and combustion. **(3.2c)**

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/pub/chemist.pdf

Standard 6: Interconnectedness: Common Themes—Equilibrium and Stability

Key Idea 4: Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Energy and Matter

- The total amount of energy and matter in closed systems 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.

Stability and Change

Much of science deals with constructing explanations of how things change and how they remain stable.

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PH

Physics

PH | Unit 1

Measurement and Mathematics through Kinematics

RECOMMENDED TIME: 15 DAYS

Unit Overview:

Fundamental forces govern all the interactions of the universe. The interaction of masses is determined by the gravitational force; the interaction of charges is determined by the electro-weak force; the interaction between particles in the nucleus is controlled by the strong force. Changes in the motion of an object require a force. Newton's laws can be used to explain and predict the motion of an object.

Essential Question:

How can measurement be used to describe an action?

Key Ideas:

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (5.1d)

- An object in linear motion may travel with a constant velocity* or with acceleration*. (5.1d)

(Note: Testing of acceleration will be limited to cases in which acceleration is constant.)

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 6: Interconnectedness: Common Themes

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Key Idea 6: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

continued

	MST STANDARDS http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf	NGSS CROSS-CUTTING CONCEPTS http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf
	Standard 7: Interdisciplinary Problem Solving **Key Idea 1:** The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena. **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.	■ 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). **Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ■ 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. ■ 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. ■ Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, analyze the specific results based on explanations in the text.

RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11–12 texts and topics.

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.

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.

WHST.9–12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

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.

WHST.9–12.9: Draw evidence from informational texts to support analysis, reflection, and research.

continued

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 1: Questioning, Analysis, and Interpretation Skills

- Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose.
- Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena.
- Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data.
- Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources.
- Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes.
- Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena.

continued

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/PHYSICS THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/physics-rt/physics06tbl.pdf

[Refer To Appendix D – Reference Tables For Physical Setting/Physics]

Prefixes for Powers of 10 (p1)

Geometry and Trigonometry (p5)

COMMON CORE STATE STANDARDS **http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf** **http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf**	**ENVIRONMENTAL GUIDELINES FOR LEARNING** **http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf**	
Mathematics **HSN-Q.A.1:** Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2:** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3:** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **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. **HSA.CED.A.4:** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law $V = IR$ to highlight resistance R. Represent and model with vector quantities. **HSN.VM.A.1:** Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v). **HSN-VM.A.2:** Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point. **HSN-VM.A.2:** Solve problems involving velocity and other quantities that can be represented by vectors. **HSN-VM.A.4:** Add and subtract vectors. **HSN-VM.A.5:** Multiply a vector by a scalar.	■ Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.	

PH Unit 2 Mechanics

RECOMMENDED TIME: 40 DAYS

Unit Overview:

Fundamental forces govern all the interactions of the universe. The interaction of masses is determined by the gravitational force. Changes in the motion of an object require a force. Newton's laws can be used to explain and predict the motion of an object.

Essential Question:

How are Newton's laws of motion relevant to our lives?

Key Ideas:

Key Idea 1: The Earth and celestial phenomena can be described by principles of relative motion and perspective.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (4.1a, c, d, e, h, 5.1b-h, j, k, l, n-u)

- An object in linear motion may travel with a constant velocity* or with acceleration*. **(5.1d)**

(Note: Testing of acceleration will be limited to cases in which acceleration is constant.)

- A vector may be resolved into perpendicular components.* **(5.1b)**
- The resultant of two or more vectors, acting at any angle, is determined by vector addition. **(5.1c)**
- When the net force on a system is zero, the system is in equilibrium. **(5.1j)**
- An object in free fall accelerates due to the force of gravity.* Friction and other forces cause the actual motion of a falling object to deviate from its theoretical motion. **(5.1e)**

(Note: Initial velocities of objects in free fall may be in any direction.)

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 2: Information Systems

Students will access, generate, process, and transfer information using appropriate technologies.

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Mathematical representations are needed to identify some patterns.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/next-generation-science-standards**
■ According to Newton's First Law, the inertia of an object is directly proportional to its mass. An object remains at rest or moves with constant velocity, unless acted upon by an unbalanced force. **(5.1i)** ■ According to Newton's Second Law, an unbalanced force causes a mass to accelerate*.**(5.1k)** ■ According to Newton's Third Law, forces occur in action/reaction pairs. When one object exerts a force on a second, the second exerts a force on the first that is equal in magnitude and opposite in direction. **(5.1q)** ■ The path of a projectile is the result of the simultaneous effect of the horizontal and vertical components of its motion; these components act independently. **(5.1f)** ■ A projectile's time of flight is dependent upon the vertical component of its motion. **(5.1g)** ■ The horizontal displacement of a projectile is dependent upon the horizontal component of its motion and its time of flight. **(5.1h)** ■ Centripetal force* is the net force which produces centripetal acceleration.* In uniform circular motion, the centripetal force is perpendicular to the tangential velocity. **(5.1n)** ■ Weight is the gravitational force with which a planet attracts a mass*. The mass of an object is independent of the gravitational field in which it is located. **(5.1l)** ■ Field strength* and direction are determined using a suitable test particle. **(5.1s)** *(Notes: 1) Calculations are limited to electrostatic and gravitational fields. 2) The gravitational field near the surface of Earth and the electrical field between two oppositely charged parallel plates are treated as uniform.)*	**Key Idea 3:** The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems. **Key Idea 4:** Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium). **Key Idea 5:** Identifying patterns of change is necessary for making predictions about future behavior and conditions. **Standard 7: Interdisciplinary Problem Solving** Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions. **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.	■ Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. ■ Patterns observable at one scale may not be observable or exist at other scales. **Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ■ 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. ■ Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ■ 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.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf**		
■ Gravitational forces are only attractive, whereas electrical and magnetic forces can be attractive or repulsive. **(5.1t)** ■ The inverse square law applies to electrical* and gravitational* fields produced by point sources. **(5.1u)** ■ Work done against friction results in an increase in the internal energy of the system. **(4.1h)** ■ Kinetic friction* is a force that opposes motion. **(5.1o)** ■ The impulse* imparted to an object causes a change in its momentum.* **(5.1p)** ■ Momentum is conserved in a closed system.* **(5.1r)** *(Note: Testing will be limited to momentum in one dimension.)* ■ All energy transfers are governed by the law of conservation of energy.* **(4.1a)** ■ Potential energy is the energy an object possesses by virtue of its position or condition. Types of potential energy include gravitational* and elastic.* **(4.1c)** ■ Kinetic energy* is the energy an object possesses by virtue of its motion. **(4.1d)** ■ In an ideal mechanical system, the sum of the macroscopic kinetic and potential energies (mechanical energy) is constant.* **(4.1e)** *(Note: Items with asterisks* require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*		

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure:

RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11–12 texts and topics.

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.

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.

WHST.11-12.7: 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.

WHST.11-12.9: Draw evidence from informational texts to support analysis, reflection, and research.

continued

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 1: Questioning, Analysis, and Interpretation Skills

- Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose.
- Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena.
- Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data.
- Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources.
- Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes.
- Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena.

continued

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/PHYSICS THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/physics-rt/physics06tbl.pdf

[Refer To Appendix D – Reference Tables For Physical Setting/Physics]

List of Physical Constants (p1)

Approximate Coefficients of Friction (p1)

Mechanics (p6)

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

Mathematics

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. Represent and model with vector quantities.

HSN.VM.A.1: Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v).

HSN.VM.A.2: Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point.

HSN.VM.A.3: Solve problems involving velocity and other quantities that can be represented by vectors. Perform operations on vectors.

HSN.VM.B.4: Add and subtract vectors.

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

- Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth.

Strand 2.4: Environment and Society

- Guideline D—Technology—Learners are able to examine the social and environmental impacts of various technologies and technological systems.

PH | Unit 3 Energy

RECOMMENDED TIME: 15 DAYS

Unit Overview:

The law of conservation of energy provides one of the basic keys to understanding the universe. The fundamental tenet of this law is that the total mass-energy of the universe is constant; however, energy can be transferred in many ways. Historically, scientists have treated the law of conservation of matter and energy separately. All energy can be classified as either kinetic or potential. When work is done on or by a system, the energy of the system changes. This relationship is known as the work-energy theorem.

Essential Question:
How are work, power, and energy related?

Key Ideas:

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

NYS SCIENCE STANDARDS
http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (4.1a-j, 5.1m, 5.3 f, j)

- When work* is done on or by a system, there is a change in the total energy* of the system. **(4.1g)**
- Work done against friction results in an increase in the internal energy of the system. **(4.1h)**
- Energy may be stored in electric* or magnetic fields. This energy may be transferred through conductors or space and may be converted to other forms of energy. **(4.1j)**
- All energy transfers are governed by the law of conservation of energy.* **(4.1a)**
- Power* is the time-rate at which work is done or energy is expended. **(4.1i)**
- Among other things, mass-energy and charge are conserved at all levels (from subnuclear to cosmic). **(5.3f)**

continued

MST STANDARDS
http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

continued

NGSS CROSS-CUTTING CONCEPTS
http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- Patterns observable at one scale may not be observable or exist at other scales.
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

- The fundamental source of all energy in the universe is the conversion of mass into energy.* **(5.3j)**
- Potential energy is the energy an object possesses by virtue of its position or condition. Types of potential energy include gravitational* and elastic.* **(4.1c)**
- The elongation or compression of a spring depends upon the nature of the spring (its spring constant) and the magnitude of the applied force.* **(5.1m)**
- Kinetic energy* is the energy an object possesses by virtue of its motion. **(4.1d)**
- Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms. **(4.1b)**
- In an ideal mechanical system, the sum of the macroscopic kinetic and potential energies (mechanical energy) is constant.* **(4.1e)**
- In a non-ideal mechanical system, as mechanical energy decreases there is a corresponding increase in other energies such as internal energy.* **(4.1f)**

(Note: Items with asterisks require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 4: Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Key Idea 6: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

- Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems.
- Energy drives the cycling of matter within and between systems.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/next-generation-science-standards

- 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).

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems can be designed to do specific tasks.
- 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.
- 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.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

- The total amount of energy and matter in closed systems 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.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11-12 texts and topics.

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.

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.

Mathematics

HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

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.

continued

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 1: Questioning, Analysis, and Interpretation Skills

- Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose.
- Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena.
- Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data.
- Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources.
- Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes.
- Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena.

continued

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/PHYSICS THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/physics-rt/physics06tbl.pdf

[Refer To Appendix D – Reference Tables For Physical Setting/Physics]

List of Physical Constants (p1)

Approximate Coefficients of Friction (p1)

COMMON CORE STATE STANDARDS **http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf** **http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf**	**ENVIRONMENTAL GUIDELINES FOR LEARNING** **http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf**
HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. Represent and model with vector quantities.	■ Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses. **Strand 2: Knowledge of Environmental Processes and Systems** **Strand 2.1: The Earth as a Physical System** ■ Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth. ■ Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them. **Strand 2.2: The Living Environment** ■ Guideline D—Flow of matter and energy—Learners are able to account for environmental characteristics based on their knowledge of how matter and energy interact in living systems. **Strand 2.4: Environment and Society** ■ Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs. ■ Guideline D—Technology—Learners are able to examine the social and environmental impacts of various technologies and technological systems. ■ Guideline E—Environmental issues—Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that these scales and issues are often linked.

PH | Unit 4 Electricity and Magnetism

RECOMMENDED TIME: 25 DAYS

Unit Overview:

The law of conservation of energy provides one of the basic keys to understanding the universe. The fundamental tenet of this law is that the total mass-energy of the universe is constant; however, energy can be transferred in many ways. Historically, scientists have treated the law of conservation of matter and energy separately. All energy can be classified as either kinetic or potential. When work is done on or by a system, the energy of the system changes. This relationship is known as the work-energy theorem. Energy may be transferred by matter or by waves. Waves transfer energy without transferring mass. Most of the information scientists gather about the universe is derived by detecting and analyzing waves. This process has been enhanced through the use of digital analysis. Types of waves include mechanical and electromagnetic. All waves have the same characteristics and exhibit certain behaviors, subject to the constraints of conservation of energy. Fundamental forces govern all the interactions of the universe. The interaction of charges is determined by the electro-weak force.

Essential Question:

How is electricity related to magnetism?

Key Ideas:

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (4.1a, b, j-p, 5.1s-u, 5.3b, f)

- Gravitational forces are only attractive, whereas electrical and magnetic forces can be attractive or repulsive. **(5.1t)**
- Charge is quantized on two levels. On the atomic level, charge is restricted to multiples of the elementary charge (charge on the electron or proton). On the subnuclear level, charge appears as fractional values of the elementary charge (quarks). **(5.3b)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

- Among other things, mass-energy and charge are conserved at all levels (from subnuclear to cosmic). **(5.3f)**
- Field strength* and direction are determined using a suitable test particle. **(5.1s)**

(Notes: 1) Calculations are limited to electrostatic and gravitational fields. 2) The gravitational field near the surface of Earth and the electrical field between two oppositely charged parallel plates are treated as uniform.)

- The inverse square law applies to electrical* and gravitational* fields produced by point sources. **(5.1u)**
- All materials display a range of conductivity. At constant temperature, common metallic conductors obey Ohm's Law*. **(4.1l)**
- A circuit is a closed path in which a current* can exist. **(4.1n)**

(Note: Use conventional current.)

- All energy transfers are governed by the law of conservation of energy.* **(4.1a)**
- Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms. **(4.1b)**
- Energy may be stored in electric* or magnetic fields. This energy may be transferred through conductors or space and may be converted to other forms of energy. **(4.1j)**
- The factors affecting resistance in a conductor are length, cross-sectional area, temperature, and resistivity.* **(4.1m)**
- Circuit components may be connected in series* or in parallel*. Schematic diagrams are used to represent circuits and circuit elements. **(4.1o)**
- Electrical power* and energy* can be determined for electric circuits. **(4.1p)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 4: Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Key Idea 6: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/next-generation-science-standards

- Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments.
- Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.
- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
- Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
- Patterns observable at one scale may not be observable or exist at other scales.
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.
- 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).

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
■ Moving electric charges produce magnetic fields. The relative motion between a conductor and a magnetic field may produce a potential difference in the conductor. **(4.1k)** *(Note: Items with asterisks* require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*	**Systems and System Models:** A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. ■ Systems can be designed to do specific tasks. ■ 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. ■ 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. ■ Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. **Energy and Matter: Flows, Cycles, and Conservation:** Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior. ■ The total amount of energy and matter in closed systems 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. ■ Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems. ■ Energy drives the cycling of matter within and between systems. ■ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ■ 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. ■ 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.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, analyze the specific results based on explanations in the text.

RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11–12 texts and topics.

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.

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.

WHST.9–12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

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.

WHST.9–12.9: Draw evidence from informational texts to support analysis, reflection, and research.

continued

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 1: Questioning, Analysis, And Interpretation Skills

- Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose.
- Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena.
- Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data.
- Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources.
- Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes.
- Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena.

continued

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/PHYSICS THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/physics-rt/physics06tbl.pdf

[Refer to Appendix D – Reference Tables for Physical Setting/Physics]

List of Physical Constants (p1)

Electricity (p4)

Circuit Symbols (p4)

Resistivities at 20°C (p4)

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

Mathematics

HSN-Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

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.

HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law $V = IR$ to highlight resistance R. Represent and model with vector quantities.

HSN.VM.A.1: Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v).

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

- Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth.
- Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.

Strand 2.4: Environment and Society

- Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs.
- Guideline D—Technology—Learners are able to examine the social and environmental impacts of various technologies and technological systems.
- Guideline E—Environmental issues—Learners are familiar with a range of environmental issues at scales that range from local to national to global. They understand that these scales and issues are often linked.

Strand 3: Skills for Understanding and Addressing Environmental Issues

Strand 3.1: Skills for Analyzing and Investigating Environmental Issues

- Guideline A—Identifying and investigating issues—Learners apply their research and analytical skills to investigate environmental issues ranging from local issues to those that are regional or global in scope.
- Guideline B—Sorting out the consequences of issues—Learners are able to evaluate the consequences of specific environmental changes, conditions, and issues for human and ecological systems.
- Guideline C—Identifying and evaluating alternative solutions and courses of action—Learners are able to identify and propose action strategies that are likely to be effective in particular situations and for particular purposes.
- Guideline D—Working with flexibility, creativity, and openness—While environmental issues investigations can bring to the surface deeply held views, learners are able to engage each other in peer review conducted in the spirit of open inquiry.

PH Unit 5 Waves

RECOMMENDED TIME: 25 DAYS

Unit Overview:

Energy may be transferred by matter or by waves. Waves transfer energy without transferring mass. Most of the information scientists gather about the universe is derived by detecting and analyzing waves. This process has been enhanced through the use of digital analysis. Types of waves include mechanical and electromagnetic. All waves have the same characteristics and exhibit certain behaviors, subject to the constraints of conservation of energy.

Essential Question:

How are waves used to model and explain physical phenomena?

Key Ideas:

Key Idea 4: Energy exists in many forms, and when these forms change, energy is conserved.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (4.1b, 4.3a-n)

- An oscillating system produces waves. The nature of the system determines the type of wave produced. **(4.3a)**
- Waves carry energy and information without transferring mass. This energy may be carried by pulses or periodic waves. **(4.3b)**
- The model of a wave incorporates the characteristics of amplitude, wavelength,* frequency*, period*, wave speed*, and phase. **(4.3c)**
- When a wave strikes a boundary between two media, reflection*, transmission, and absorption occur. A transmitted wave may be refracted. **(4.3h)**
- Mechanical waves require a material medium through which to travel. **(4.3d)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.
- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.

Scale, Proportion, and Quantity:

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

continued

NYS SCIENCE STANDARDS **http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf**	**MST STANDARDS** **http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf**	**NGSS CROSS-CUTTING CONCEPTS** **http://www.nextgenscience.org/next-generation-science-standards**
■ Waves are categorized by the direction in which particles in a medium vibrate about an equilibrium position relative to the direction of propagation of the wave, such as transverse and longitudinal waves. **(4.3e)** ■ Resonance occurs when energy is transferred to a system at its natural frequency. **(4.3f)** ■ When waves of a similar nature meet, the resulting interference may be explained using the principle of superposition. Standing waves are a special case of interference. **(4.3m)** ■ When a wave source and an observer are in relative motion, the observed frequency of the waves traveling between them is shifted (Doppler effect). **(4.3n)** ■ When a wave moves from one medium into another, the wave may refract due to a change in speed. The angle of refraction (measured with respect to the normal) depends on the angle of incidence and the properties of the media (indices of refraction).* **(4.3i)** ■ The absolute index of refraction is inversely proportional to the speed of a wave.* **(4.3j)** ■ Diffraction occurs when waves pass by obstacles or through openings. The wavelength of the incident wave and the size of the obstacle or opening affect how the wave spreads out. **(4.3l)**	**Standard 7: Interdisciplinary Problem Solving** **Key Idea 1:** The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena. **Key Idea 2:** Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results. ■ Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms. **(4.1b)** ■ Electromagnetic radiation exhibits wave characteristics. Electromagnetic waves can propagate through a vacuum. **(4.3g)** ■ All frequencies of electromagnetic radiation travel at the same speed in a vacuum.* **(4.3k)** *(Note: Items with asterisks* require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*	■ The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ■ Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. ■ Patterns observable at one scale may not be observable or exist at other scales. ■ Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. ■ 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). **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ■ 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. ■ 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.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

RST.11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, analyze the specific results based on explanations in the text.

RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11–12 texts and topics.

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.

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.

WHST.9–12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

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.

WHST.9–12.9: Draw evidence from informational texts to support analysis, reflection, and research.

continued

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 1: Questioning, Analysis, and Interpretation Skills

- Guideline A—Questioning—Learners are able to develop, modify, clarify, and explain questions that guide environmental investigations of various types. They understand factors that influence the questions they pose.
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- Guideline C—Collecting information—Learners are able to locate and collect reliable information for environmental investigations of many types. They know how to use sophisticated technology to collect information, including computer programs that access, gather, store, and display data.
- Guideline D—Evaluating accuracy and reliability—Learners can apply basic logic and reasoning skills to evaluate completeness and reliability in a variety of information sources.
- Guideline E—Organizing information—Learners are able to organize and display information in ways appropriate to different types of environmental investigations and purposes.
- Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena.

continued

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/PHYSICS THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/physics-rt/physics06tbl.pdf

[Refer to Appendix D – Reference Tables for Physical Setting/Physics]

List of Physical Constants (p1)

The Electromagnetic Spectrum (p2)

Absolute Indices of Refraction (p2)

Waves (p5)

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

Mathematics

HSN-Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

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.

HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. Represent and model with vector quantities.

HSN.VM.A.1: Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v).

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

- Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline A—Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth.
- Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.

PH | Unit 6 Modern Physics

RECOMMENDED TIME: 20 DAYS

Unit Overview:

Fundamental forces govern all the interactions of the universe. The interaction of masses is determined by the gravitational force; the interaction of charges is determined by the electro-weak force; the interaction between particles in the nucleus is controlled by the strong force. Changes in the motion of an object require a force. Newton's laws can be used to explain and predict the motion of an object. On the atomic level, the quantum nature of the fundamental forces becomes evident. Models of the atom have been developed to incorporate wave-particle duality, quantization, and the conservation laws. These models have been modified to reflect new observations; they continue to evolve. Everyday experiences are manifestations of patterns that repeat themselves, from the subnuclear to the cosmic level. Models that are used at each level reflect these patterns. The future development of physics is likely to be derived from these realms.

Essential Question:

How does our understanding of the atom change with new technologies?

Key Ideas:

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Major Understandings:

Quoted from the New York State Performance Indicators (4.1b, 5.3a-j)

- On the atomic level, energy and matter exhibit the characteristics of both waves and particles. **(5.3e)**
- States of matter and energy are restricted to discrete values (quantized). **(5.3a)**
- On the atomic level, energy is emitted or absorbed in discrete packets called photons.* **(5.3c)**
- The energy of a photon is proportional to its frequency.* **(5.3d)**

continued

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Standard 2: Information Systems

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Standard 6: Interconnectedness: Common Themes

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

continued

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

Patterns:

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- 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.
- Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments.
- Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

continued

NYS SCIENCE STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

- Behaviors and characteristics of matter, from the microscopic to the cosmic levels, are manifestations of its atomic structure. The macroscopic characteristics of matter, such as electrical and optical properties, are the result of microscopic interactions. **(5.3h)**
- Energy may be converted among mechanical, electromagnetic, nuclear, and thermal forms. **(4.1b)** 🍃
- Charge is quantized on two levels. On the atomic level, charge is restricted to multiples of the elementary charge (charge on the electron or proton). On the subnuclear level, charge appears as fractional values of the elementary charge (quarks). **(5.3b)**
- Among other things, mass-energy and charge are conserved at all levels (from subnuclear to cosmic). **(5.3f)**
- The Standard Model of Particle Physics has evolved from previous attempts to explain the nature of the atom and states that: **(5.3g)**
    - atomic particles are composed of subnuclear particles
    - the nucleus is a conglomeration of quarks which manifest themselves as protons and neutrons
    - each elementary particle has a corresponding antiparticle
- The total of the fundamental interactions is responsible for the appearance and behavior of the objects in the universe. **(5.3i)**
- The fundamental source of all energy in the universe is the conversion of mass into energy.* **(5.3j)**

(Note: Items with asterisks require quantitative treatment per the Reference Table for Physics. Asterisks following individual words refer to the preceding word or phrase only; asterisks appearing after the final period of a sentence refer to all concepts or ideas presented in the sentence.)*

MST STANDARDS

http://www.p12.nysed.gov/ciai/mst/sci/documents/phycoresci.pdf

Key Idea 3: The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Key Idea 4: Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Standard 7: Interdisciplinary Problem Solving

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/society, consumer decision making, design, and inquiry into phenomena.

Key Idea 2: Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results.

NGSS CROSS-CUTTING CONCEPTS

http://www.nextgenscience.org/next-generation-science-standards

- Mathematical representations are needed to identify some patterns.
- Empirical evidence is needed to identify patterns.

Systems and System Models:

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- 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.
- 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.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Energy and Matter: Flows, Cycles, and Conservation:

Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.

- The total amount of energy and matter in closed systems 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.
- Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems.

continued

		NGSS CROSS-CUTTING CONCEPTS **http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf**
		▪ Energy drives the cycling of matter within and between systems. ▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions. ▪ 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. ▪ 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. **Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. ▪ Much of science deals with constructing explanations of how things change and how they remain stable. ▪ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

ELA/Literacy

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RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 11–12 texts and topics.

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.

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.

WHST.9–12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

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.

WHST.9–12.9: Draw evidence from informational texts to support analysis, reflection, and research.

continued

ENVIRONMENTAL GUIDELINES FOR LEARNING

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- Guideline B—Designing investigations—Learners know how to design investigations to answer particular questions about the environment. They are able to develop approaches for investigating unfamiliar types of problems and phenomena.
- Guideline F—Working with models and simulations—Learners are able to create, use, and evaluate models to understand environmental phenomena.
- Guideline G—Drawing conclusions and developing explanations—Learners are able to use evidence and logic in developing proposed explanations that address their initial questions and hypotheses.

Strand 2: Knowledge of Environmental Processes and Systems

Strand 2.1: The Earth as a Physical System

- Guideline B—Changes in matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena.
- Guideline C—Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.

continued

TABLES: REFERENCE TABLES FOR PHYSICAL SETTING/PHYSICS THAT ARE RELEVANT TO THE UNIT

http://www.p12.nysed.gov/assessment/reftable/physics-rt/physics06tbl.pdf

[Refer to Appendix D – Reference Tables for Physical Setting/Physics]

List of Physical Constants (p1)

Energy Level Diagrams (p3)

Classification of Matter (p3)

Particles of the Standard Model (p3)

Modern Physics (p5)

COMMON CORE STATE STANDARDS

http://www.corestandards.org/wp-content/uploads/ELA_Standards.pdf
http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf

Mathematics

HSN-Q.A.1: Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

HSN-Q.A.3: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

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.

HSA.CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R. Represent and model with vector quantities.

HSN.VM.A.1: Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v).

ENVIRONMENTAL GUIDELINES FOR LEARNING

http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

Strand 2.2: The Living Environment

- Guideline C—Systems and connections—Learners understand the living environment to be comprised of interrelated, dynamic systems.
- Guideline D—Flow of matter and energy—Learners are able to account for environmental characteristics based on their knowledge of how matter and energy interact in living systems.

Strand 2.3: Humans and Their Societies

- Guideline D—Global connections—Learners are able to analyze global, social, cultural, political, economic, and environmental linkages.
- Guideline E—Change and conflict—Learners understand the functioning of public processes for promoting and managing change and conflict, and can analyze their effects on the environment.

Strand 2.4: Environment and Society

- Guideline A—Human/environment interactions—Learners understand that humans are able to alter the physical environment to meet their needs and that there are limits to the ability of the environment to absorb impacts or meet human needs.
- Guideline C—Resources—Learners understand that the importance and use of resources change over time and vary under different economic and technological systems.
- Guideline D—Technology—Learners are able to examine the social and environmental impacts of various technologies and technological systems.

Strand 3: Skills for Understanding and Addressing Environmental Issues

Strand 3.2: Decision-Making and Citizenship Skills

- Guideline A—Forming and evaluating personal views—Learners are able to communicate, evaluate, and justify their own views on environmental issues and alternative ways to address them.
- Guideline D—Evaluating the results of actions—Learners are able to evaluate the effects of their own actions and actions taken by other individuals and groups, including possible intended and unintended consequences of actions.

Grades 9-12 Cross-Cutting Concepts

Patterns: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.	■ 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. ■ Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. ■ Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. ■ Mathematical representations are needed to identify some patterns. ■ Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.	■ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ■ Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ■ Systems can be designed to cause a desired effect. ■ Changes in systems may have various causes that may not have equal effects.
Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.	■ The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ■ Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. ■ Patterns observable at one scale may not be observable or exist at other scales. ■ Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. ■ 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).
Systems and System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.	■ Systems can be designed to do specific tasks. ■ 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. ■ 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. ■ Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

continued

Grades 9-12 Cross-Cutting Concepts

Energy and Matter: Flows, Cycles, and Conservation: Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.	■ The total amount of energy and matter in closed systems 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. ■ Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems. ■ Energy drives the cycling of matter within and between systems. ■ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.
Structure and Function: The way an object is shaped or structured determines many of its properties and functions.	■ 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. ■ 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.
Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.	■ Much of science deals with constructing explanations of how things change and how they remain stable. ■ Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. ■ Feedback (negative or positive) can stabilize or destabilize a system. ■ Systems can be designed for greater or lesser stability.

Developed by NSTA using information from Appendix G of the Next Generation Science Standards © 2011, 2012, 2013 Achieve, Inc.

Adapted from: National Research Council (2011). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academy Press. Chapter 4: Crosscutting Concepts.

Grades 9-12 Engineering Design

Asking Questions and Defining Problems	Developing and Using Models	Planning and Carrying Out an Investigation	Analyzing and Interpreting Data	Using Mathematics and Computational Thinking	Constructing Explanations and Defining Solutions	Engaging in Argument From Evidence	Obtaining, Evaluating and Communicating Information
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. Ask questions: • that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. • that arise from examining models or a theory, to clarify and/or seek additional information and relationships. • to determine relationships, including quantitative relationships, between independent and dependent variables. • to clarify and refine a model, an explanation, or an engineering problem. Evaluate a question to determine if it is testable and relevant. Ask questions that can be investigated within	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. Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. Design a test of a model to ascertain its reliability. Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.	Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. 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	Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. Compare and contrast various types of data	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 and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Apply techniques of algebra and functions to represent and solve scientific and engineering problems.	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. Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. 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. Apply scientific ideas, principles, and/or evidence to provide an explanation of	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse	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. Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Compare, integrate, and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.
continued	*continued*	*continued*	*continued*	*continued*	*continued*	*continued*	*continued*

Grades

9-12 Engineering Design

Asking Questions and Defining Problems	Developing and Using Models	Planning and Carrying Out an Investigation	Analyzing and Interpreting Data	Using Mathematics and Computational Thinking	Constructing Explanations and Defining Solutions	Engaging in Argument From Evidence	Obtaining, Evaluating and Communicating Information
the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.	Develop a complex model that allows for manipulation and testing of a proposed process or system. Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	data (e.g., number of trials, cost, risk, time), and refine the design accordingly. Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. Select appropriate tools to collect, record, analyze, and evaluate data. Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.	sets (e.g., self-generated, archival) to examine consistency of measurements and observations. Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.	Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model “makes sense” by comparing the outcomes with what is known about the real world. Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).	phenomena and solve design problems, taking into account possible unanticipated effects. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support to explanation or conclusion. Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	perspectives, and determining additional information required to resolve contradictions. Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence. Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process).

Appendix A

NYSED Mandated Instruction in Science

New York State Education Law: Article 17, Sections 809–810

809. Instruction in the humane treatment of animals

Summary:

1. Instruction. Every elementary school under state control or supported wholly or partly by public money of the state, must give instruction in the humane treatment and protection of animals and the importance of the part they play in the economy of nature as well as the necessity of controlling the proliferation of animals which are subsequently abandoned and caused to suffer extreme cruelty. Such instruction shall be for such period of time during each school year as the board of regents may prescribe and may be joined with work in literature, reading, language, nature study or ethnology. Such weekly instruction may be divided into two or more periods. A school district shall not be entitled to participate in the public school money on account of any school or the attendance at any school subject to the provisions of this section, if the instruction required hereby is not given.

2. Study and care of live animals. Any school which cares for or uses animals for study shall ensure that each animal in such school be afforded the following: appropriate quarters; sufficient space for the normal behavior and postural requirements of the species; proper ventilation, lighting, and temperature control; adequate food and clean drinking water; and quarters which shall be cleaned on a regular basis and located in an area where undue stress and disturbance are minimized.

3. Application. The provisions of this section shall not be construed to prohibit or constrain vocational instruction in the normal practice of animal husbandry, or prohibit or constrain instruction in environmental education activities as established by the department of environmental conservation.

4. Dissection of animals. Any student expressing a moral or religious objection to the performance or witnessing of the dissection of an animal, either wholly or in part, shall be provided the opportunity to undertake and complete an alternative project that shall be approved by such student's teacher; provided, however, that such objection is substantiated in writing by the student's parent or legal guardian. Students who perform alternative projects who do not perform or witness the dissection of animals shall not be penalized.

5. Treatment of live vertebrate animals. a. Except as provided for in this subdivision, no school district, school principal, administrator, or teacher shall require or permit the performance of a lesson or experimental study on a live vertebrate animal in any such school or during any activity conducted under the auspices of such school whether or not the activity takes place on the premises of such school where such lesson or experimental study employs: (i) micro-organisms which cause disease in humans or animals, (ii) ionizing radiation, (iii) known cancer producing agents, (iv) chemicals at toxic levels, (v) drugs producing pain or deformity, (vi) severe extremes of temperature, (vii) electric or other shock, (viii) excessive noise, (ix) noxious fumes, (x) exercise to exhaustion, (xi) overcrowding, (xii) paralysis by muscle relaxants or other means, (xiii) deprivation or excess of food, water or other essential nutrients, (xiv) surgery or other invasive procedures, (xv) other extreme stimuli, or (xvi) termination of life. b. Notwithstanding any inconsistent provision of this section, the commissioner may, upon the submission of a written program plan, issue to such school a written waiver of such restrictions for students subject to the following provisions: (i) the student shall be in grade ten, eleven, or twelve; and (ii) the student shall be under the supervision of one or more teachers certified in science; and (iii) the student shall be pursuing an accelerated course of study in the sciences as defined by the commissioner in preparation for taking a state or national advanced placement examination. The commissioner shall issue a waiver of such restrictions for any teacher certified in science instructing such student. The written program plan shall include, but not be limited to: (i) the educational basis for requesting a waiver; (ii) the objective of the lesson or experiment; (iii) the methods and techniques to be used; and (iv) any other information required by the commissioner.

6. Report. On or before the first day of January next succeeding the effective date of this amended section, the commissioner shall annually submit a report to the governor and the legislature which shall include, but not be limited to, the number of written program plan proposals submitted by schools and the number of such proposals subsequently approved by the commissioner. In those cases where a program plan proposal has been approved by the commissioner, such plan shall be appended to and become a part of the commissioner's annual report.

810. Conservation Day

Summary:

The last Friday in April each year is declared to be known as Conservation Day.

Every school and teacher or instructor shall encourage the planting, protection and preservation of trees, shrubs and the best methods to accomplish these results and to provide lectures, pictures or tours to increase the students' interest in fish and wildlife, soil and water of the state.

The commissioner of education may prescribe from time to time a course of exercises and instruction in the subjects hereinbefore mentioned, which shall be adopted and observed by the public school authorities on Conservation Day. Upon receipt of copies of such course sufficient in number to supply all the schools under their supervision, the school authorities aforesaid shall promptly provide each of the schools under their charge with a copy, and cause it to be observed.

NOTE: Conservation Day should not be confused with Earth Day, which falls on April 22 each year.

The University of the State of New York • THE STATE EDUCATION DEPARTMENT • Albany, New York 12234 • www.nysed.gov

Reference Tables for Physical Setting/EARTH SCIENCE

Radioactive Decay Data

RADIOACTIVE ISOTOPE	DISINTEGRATION	HALF-LIFE (years)
Carbon-14	$^{14}\text{C} \rightarrow {}^{14}\text{N}$	5.7×10^{3}
Potassium-40	$^{40}\text{K} \begin{smallmatrix} \nearrow {}^{40}\text{Ar} \\ \searrow {}^{40}\text{Ca} \end{smallmatrix}$	1.3×10^{9}
Uranium-238	$^{238}\text{U} \rightarrow {}^{206}\text{Pb}$	4.5×10^{9}
Rubidium-87	$^{87}\text{Rb} \rightarrow {}^{87}\text{Sr}$	4.9×10^{10}

Specific Heats of Common Materials

MATERIAL	SPECIFIC HEAT (Joules/gram • °C)
Liquid water	4.18
Solid water (ice)	2.11
Water vapor	2.00
Dry air	1.01
Basalt	0.84
Granite	0.79
Iron	0.45
Copper	0.38
Lead	0.13

Equations

$$\text{Eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}}$$

$$\text{Gradient} = \frac{\text{change in field value}}{\text{distance}}$$

$$\text{Rate of change} = \frac{\text{change in value}}{\text{time}}$$

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Properties of Water

Heat energy gained during melting . . . . 334 J/g

Heat energy released during freezing . . . . 334 J/g

Heat energy gained during vaporization . . . . . 2260 J/g

Heat energy released during condensation . . . 2260 J/g

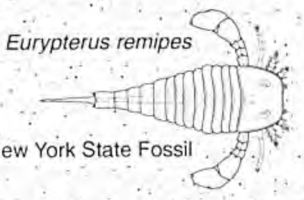
Density at 3.98°C . . . . 1.0 g/mL

Average Chemical Composition of Earth's Crust, Hydrosphere, and Troposphere

ELEMENT (symbol)	CRUST		HYDROSPHERE	TROPOSPHERE
	Percent by mass	Percent by volume	Percent by volume	Percent by volume
Oxygen (O)	46.10	94.04	33.0	21.0
Silicon (Si)	28.20	0.88		
Aluminum (Al)	8.23	0.48		
Iron (Fe)	5.63	0.49		
Calcium (Ca)	4.15	1.18		
Sodium (Na)	2.36	1.11		
Magnesium (Mg)	2.33	0.33		
Potassium (K)	2.09	1.42		
Nitrogen (N)				78.0
Hydrogen (H)			66.0	
Other	0.91	0.07	1.0	1.0

2011 EDITION

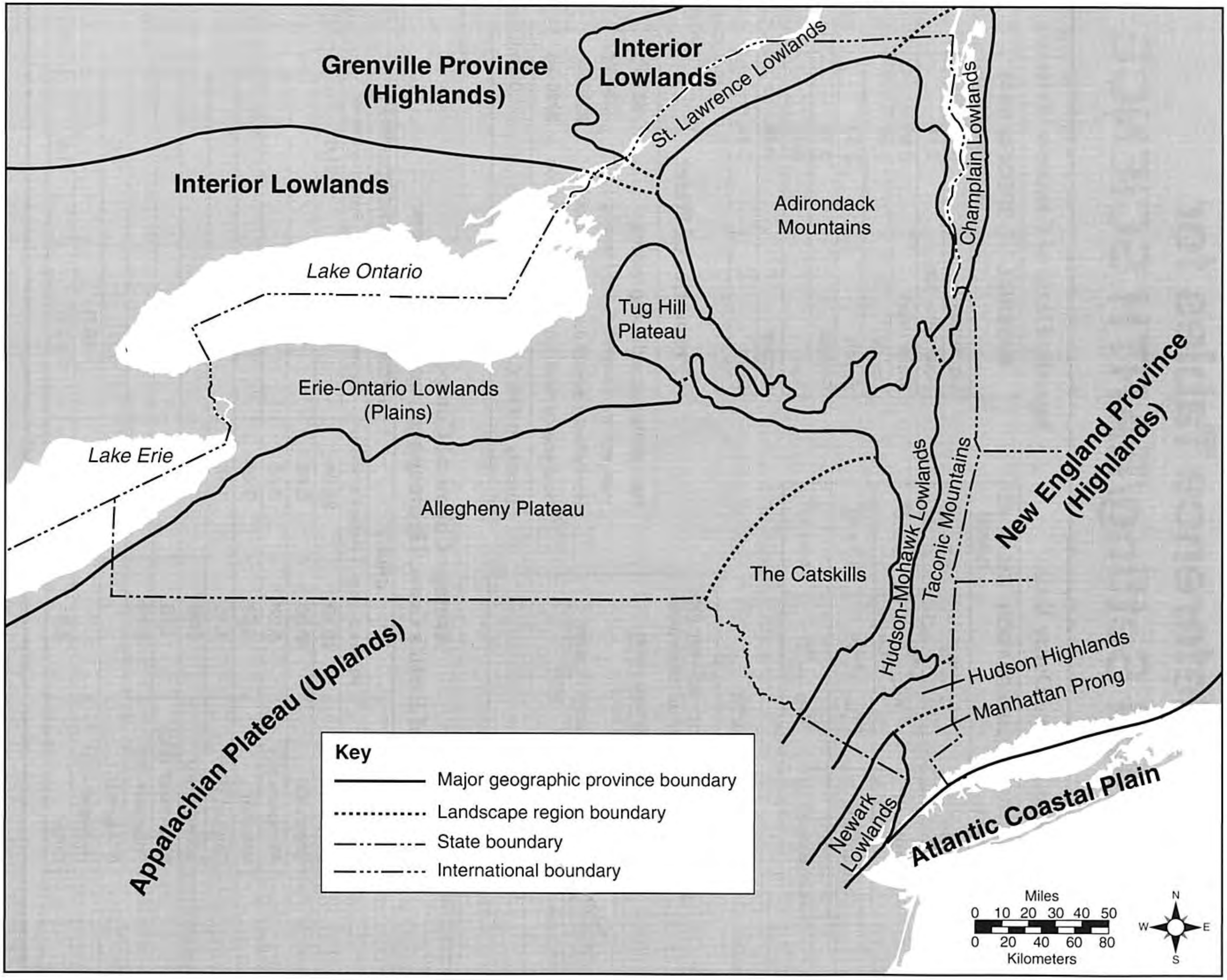
This edition of the Earth Science Reference Tables should be used in the classroom beginning in the 2011–12 school year. The first examination for which these tables will be used is the January 2012 Regents Examination in Physical Setting / Earth Science.



Eurypterus remipes

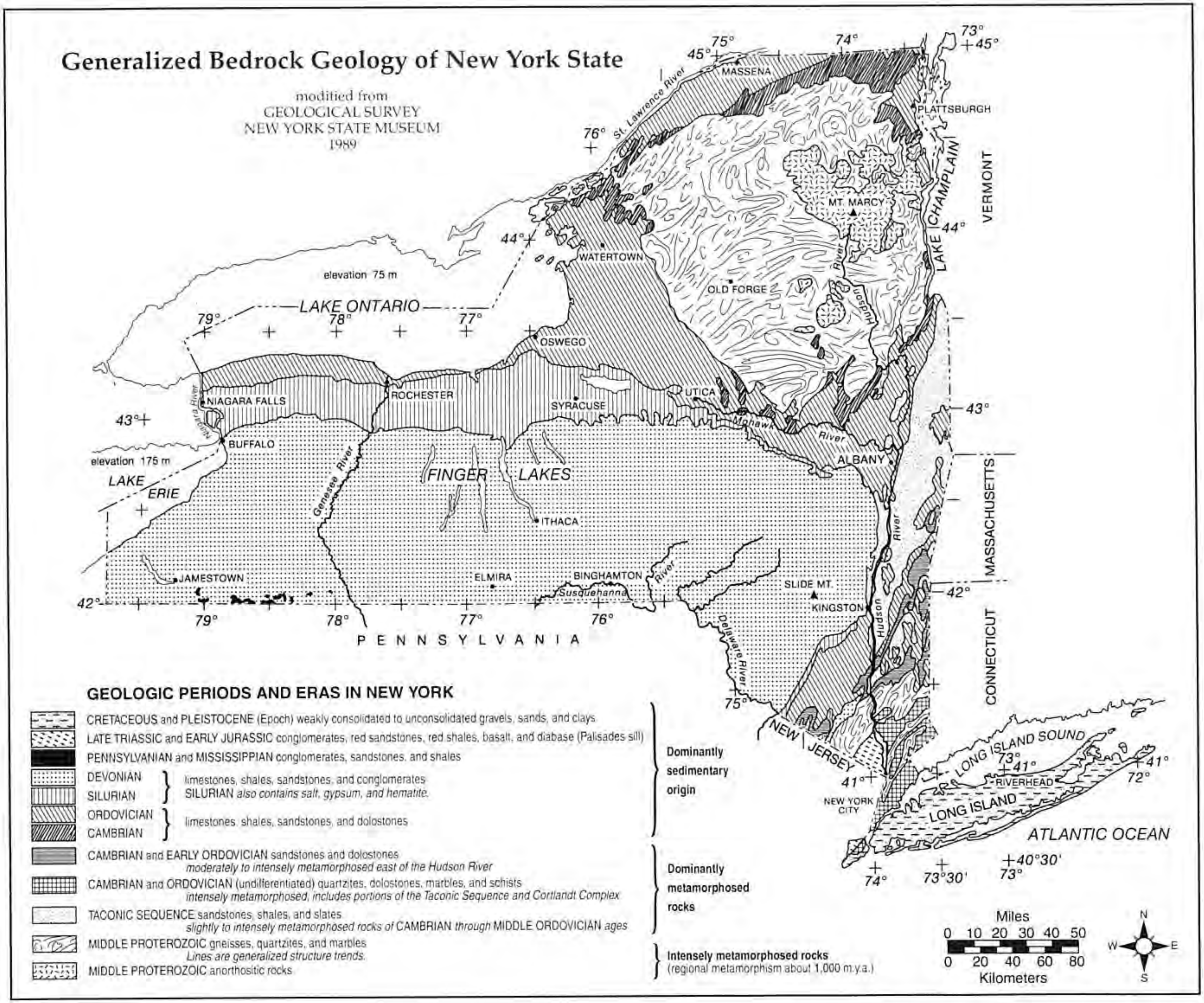
New York State Fossil

Generalized Landscape Regions of New York State

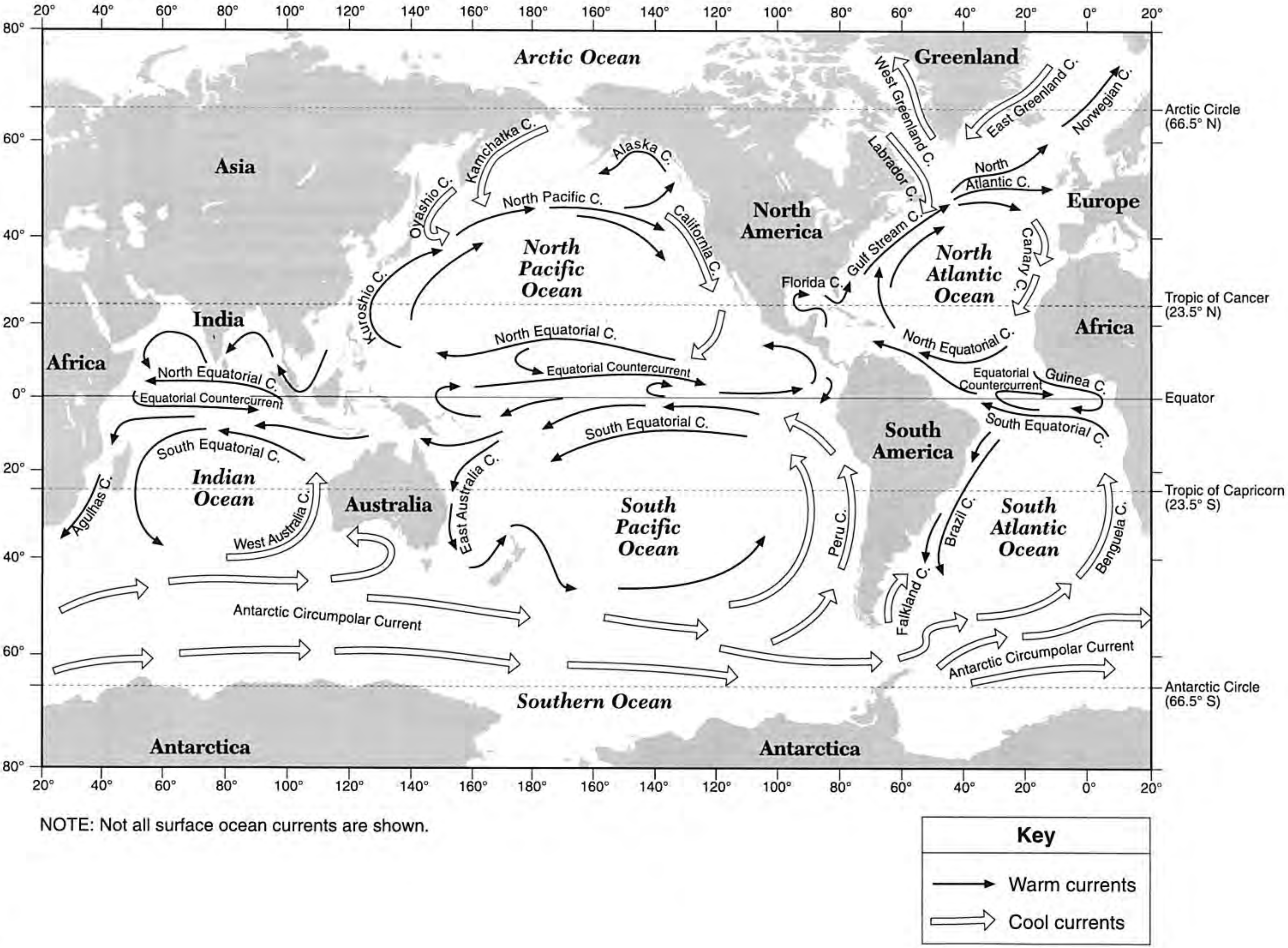


Generalized Bedrock Geology of New York State

modified from
GEOLOGICAL SURVEY
NEW YORK STATE MUSEUM
1989

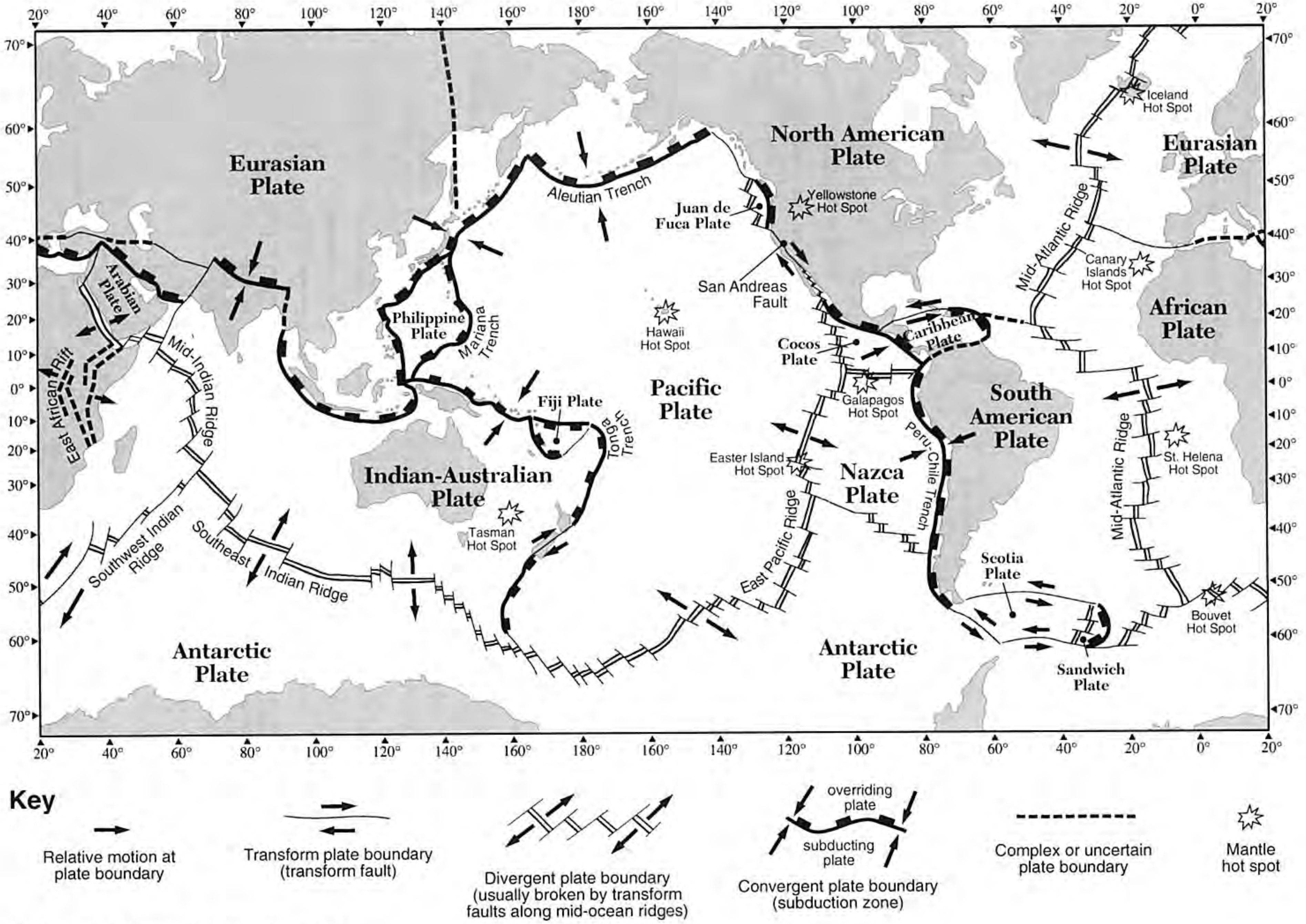


Surface Ocean Currents



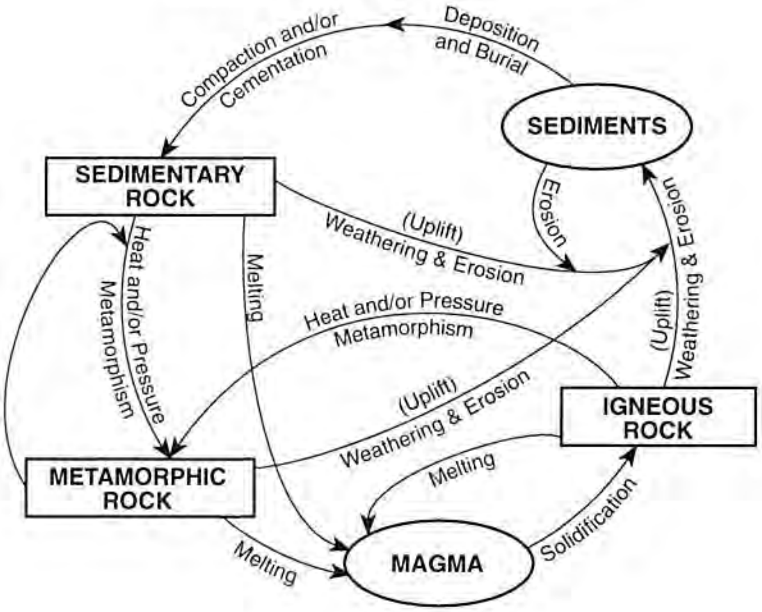
NOTE: Not all surface ocean currents are shown.

Tectonic Plates

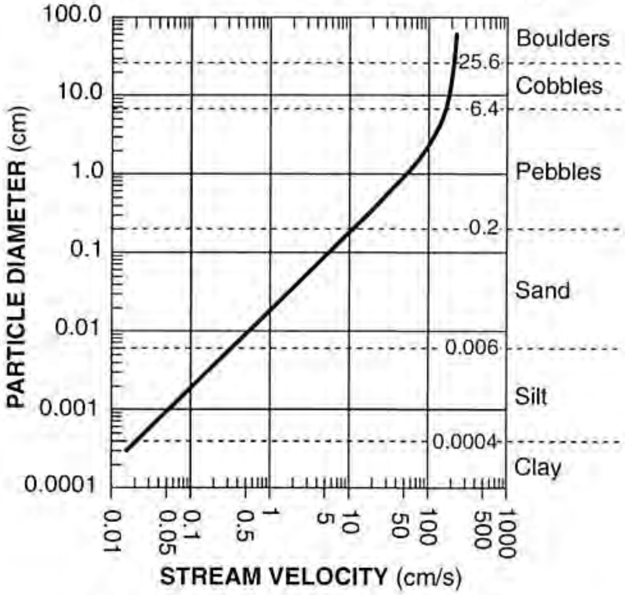


NOTE: Not all mantle hot spots, plates, and boundaries are shown.

Rock Cycle in Earth's Crust

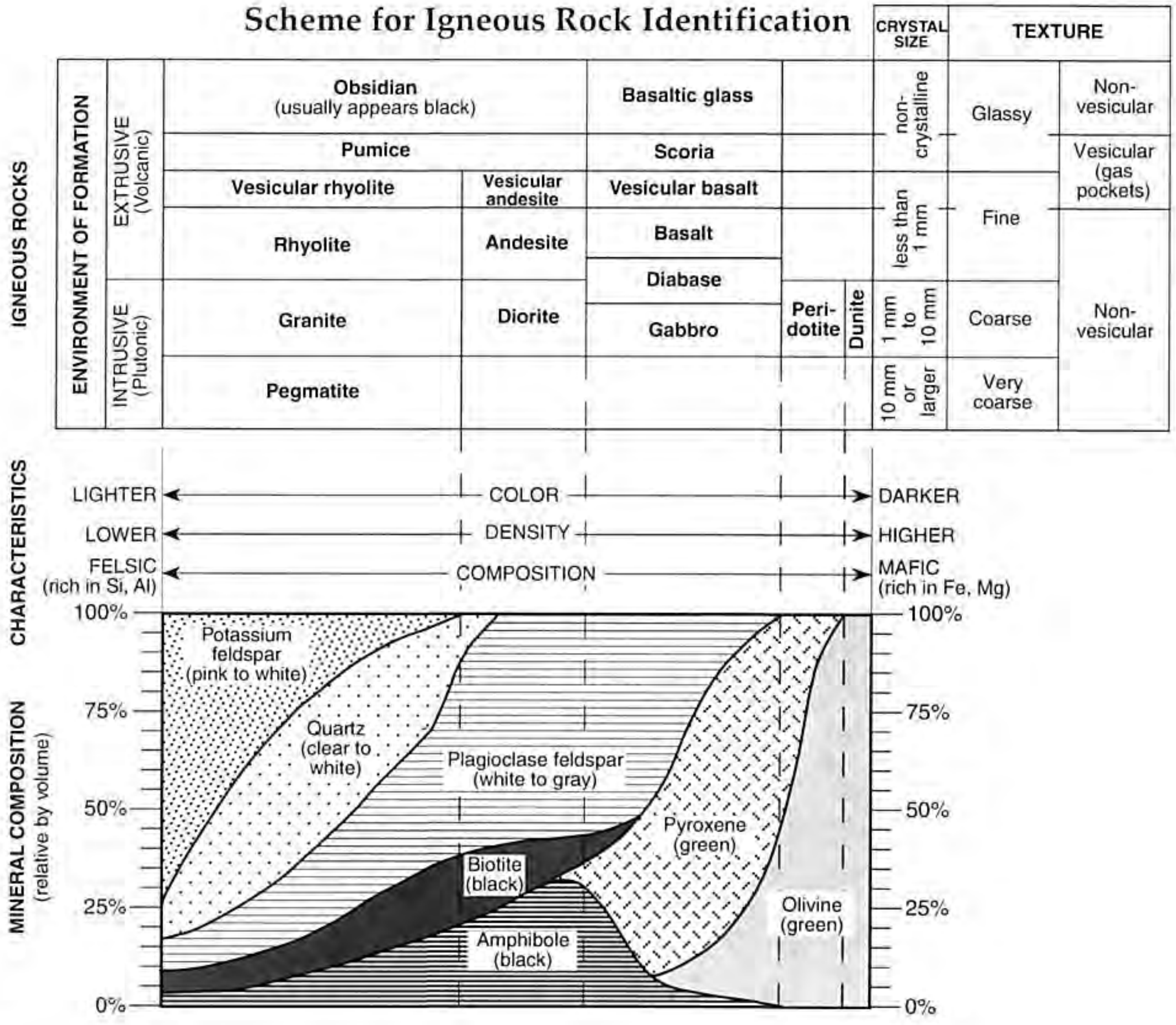


Relationship of Transported Particle Size to Water Velocity



This generalized graph shows the water velocity needed to maintain, but not start, movement. Variations occur due to differences in particle density and shape.

Scheme for Igneous Rock Identification



Scheme for Sedimentary Rock Identification

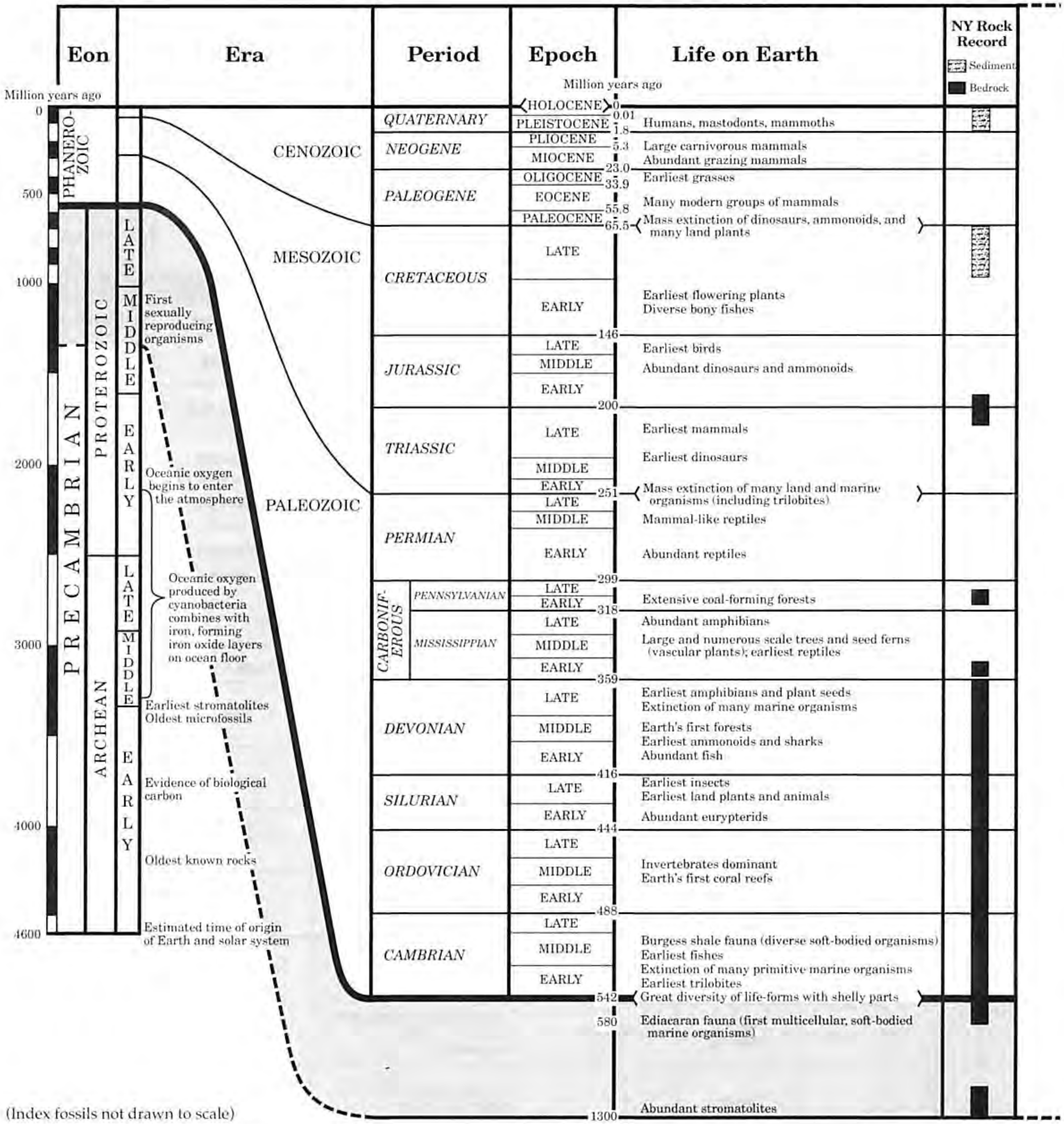
INORGANIC LAND-DERIVED SEDIMENTARY ROCKS					
TEXTURE	**GRAIN SIZE**	**COMPOSITION**	**COMMENTS**	**ROCK NAME**	**MAP SYMBOL**
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments	**Conglomerate**	◌
			Angular fragments	**Breccia**	◇
	Sand (0.006 to 0.2 cm)		Fine to coarse	**Sandstone**	⁙
	Silt (0.0004 to 0.006 cm)		Very fine grain	**Siltstone**	┅
	Clay (less than 0.0004 cm)		Compact; may split easily	**Shale**	☰

CHEMICALLY AND/OR ORGANICALLY FORMED SEDIMENTARY ROCKS					
TEXTURE	**GRAIN SIZE**	**COMPOSITION**	**COMMENTS**	**ROCK NAME**	**MAP SYMBOL**
Crystalline	Fine to coarse crystals	Halite	Crystals from chemical precipitates and evaporites	**Rock salt**	▦
		Gypsum		**Rock gypsum**	▨
		Dolomite		**Dolostone**	▱
Crystalline or bioclastic	Microscopic to very coarse	Calcite	Precipitates of biologic origin or cemented shell fragments	**Limestone**	▤
Bioclastic		Carbon	Compacted plant remains	**Bituminous coal**	▬

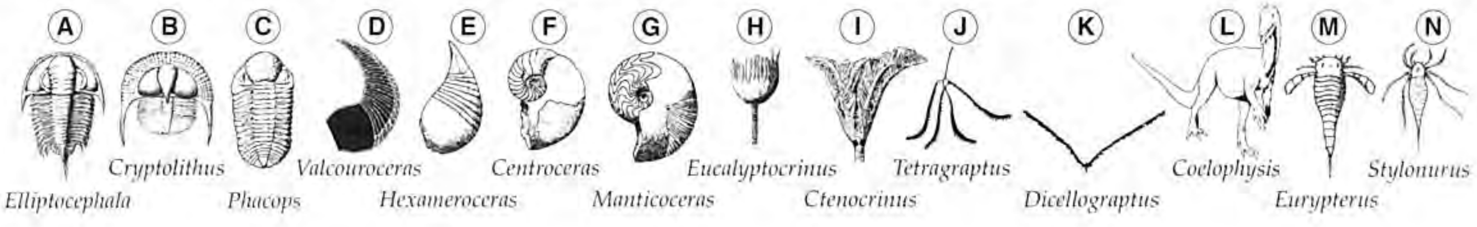
Scheme for Metamorphic Rock Identification

TEXTURE		**GRAIN SIZE**	**COMPOSITION**	**TYPE OF METAMORPHISM**	**COMMENTS**	**ROCK NAME**	**MAP SYMBOL**
FOLIATED	MINERAL ALIGNMENT	Fine	MICA	Regional (Heat and pressure increases) ↓	Low-grade metamorphism of shale	**Slate**	▨
		Fine to medium	MICA QUARTZ FELDSPAR AMPHIBOLE GARNET		Foliation surfaces shiny from microscopic mica crystals	**Phyllite**	≋
					Platy mica crystals visible from metamorphism of clay or feldspars	**Schist**	▧
	BAND-ING	Medium to coarse	MICA QUARTZ FELDSPAR AMPHIBOLE GARNET PYROXENE		High-grade metamorphism; mineral types segregated into bands	**Gneiss**	≈
NONFOLIATED		Fine	Carbon	Regional	Metamorphism of bituminous coal	**Anthracite coal**	■
		Fine	Various minerals	Contact (heat)	Various rocks changed by heat from nearby magma/lava	**Hornfels**	⌗
		Fine to coarse	Quartz	Regional or contact	Metamorphism of quartz sandstone	**Quartzite**	⁄
			Calcite and/or dolomite		Metamorphism of limestone or dolostone	**Marble**	⊞
		Coarse	Various minerals		Pebbles may be distorted or stretched	**Metaconglomerate**	◌

GEOLOGIC HISTORY



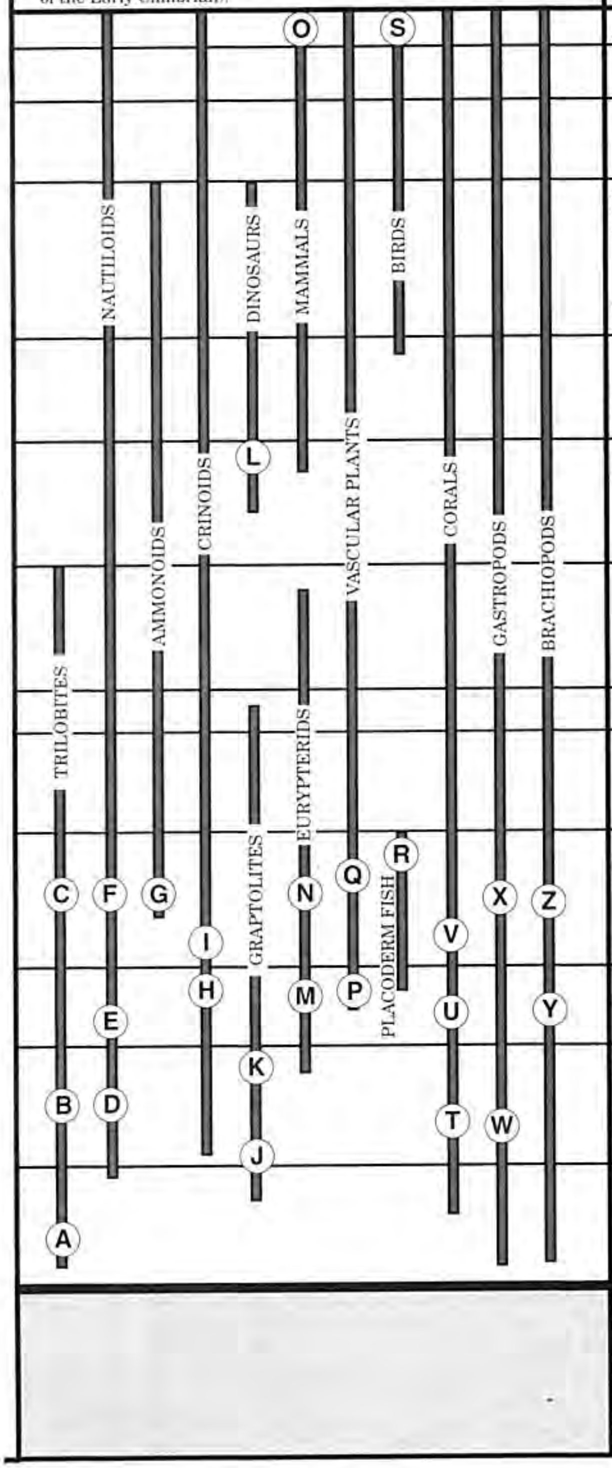
(Index fossils not drawn to scale)



OF NEW YORK STATE

Time Distribution of Fossils (including important fossils of New York)

The center of each lettered circle indicates the approximate time of existence of a specific index fossil (e.g. Fossil Ⓐ lived at the end of the Early Cambrian).



Important Geologic Events in New York

Advance and retreat of last continental ice

Sands and clays underlying Long Island and Staten Island deposited on margin of Atlantic Ocean

Dome-like uplift of Adirondack region begins

Initial opening of Atlantic Ocean
North America and Africa separate

❬ Intrusion of Palisades sill ❭

Pangaea begins to break up

Alleghenian orogeny caused by collision of North America and Africa along transform margin, forming Pangaea

Catskill delta forms
Erosion of Acadian Mountains

Acadian orogeny caused by collision of North America and Avalon and closing of remaining part of Iapetus Ocean

Salt and gypsum deposited in evaporite basins

Erosion of Taconic Mountains; Queenston delta forms

Taconian orogeny caused by closing of western part of Iapetus Ocean and collision between North America and volcanic island arc

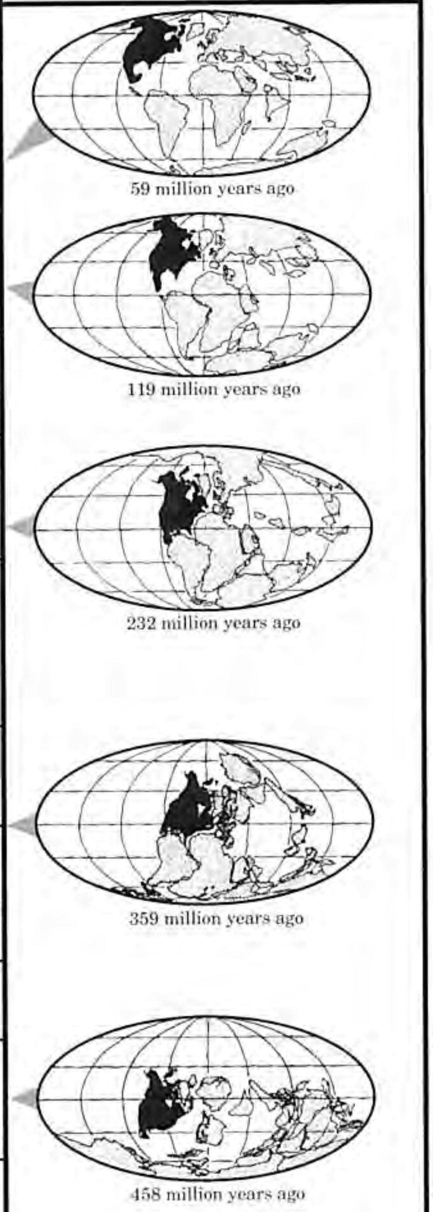
Widespread deposition over most of New York along edge of Iapetus Ocean

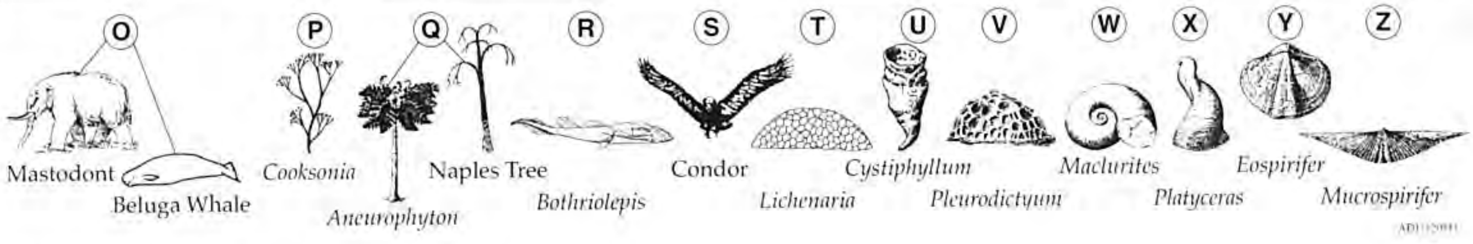
Rifting and initial opening of Iapetus Ocean

Erosion of Grenville Mountains

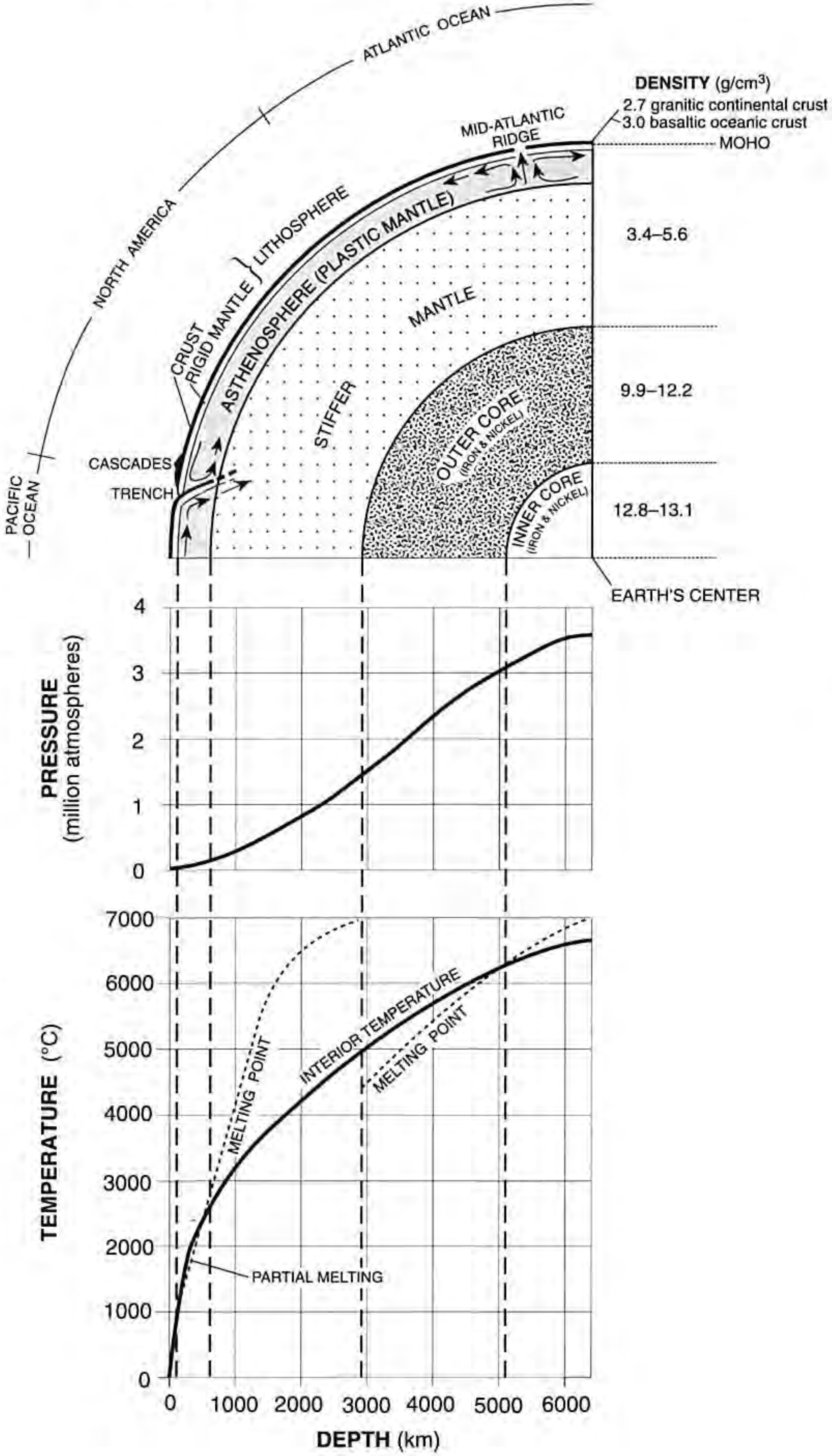
Grenville orogeny: metamorphism of bedrock now exposed in the Adirondacks and Hudson Highlands

Inferred Positions of Earth's Landmasses

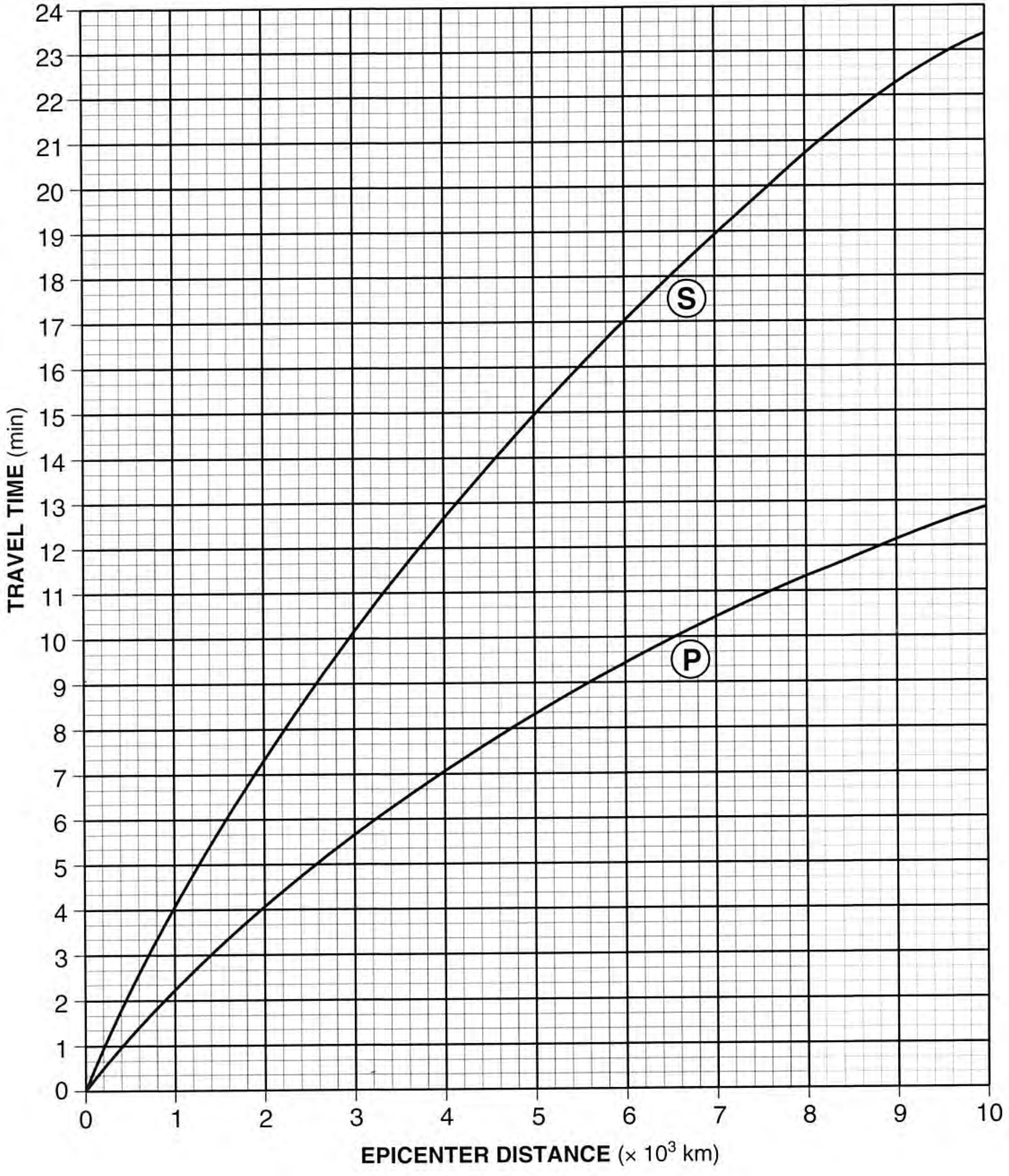




Inferred Properties of Earth's Interior



Earthquake P-Wave and S-Wave Travel Time



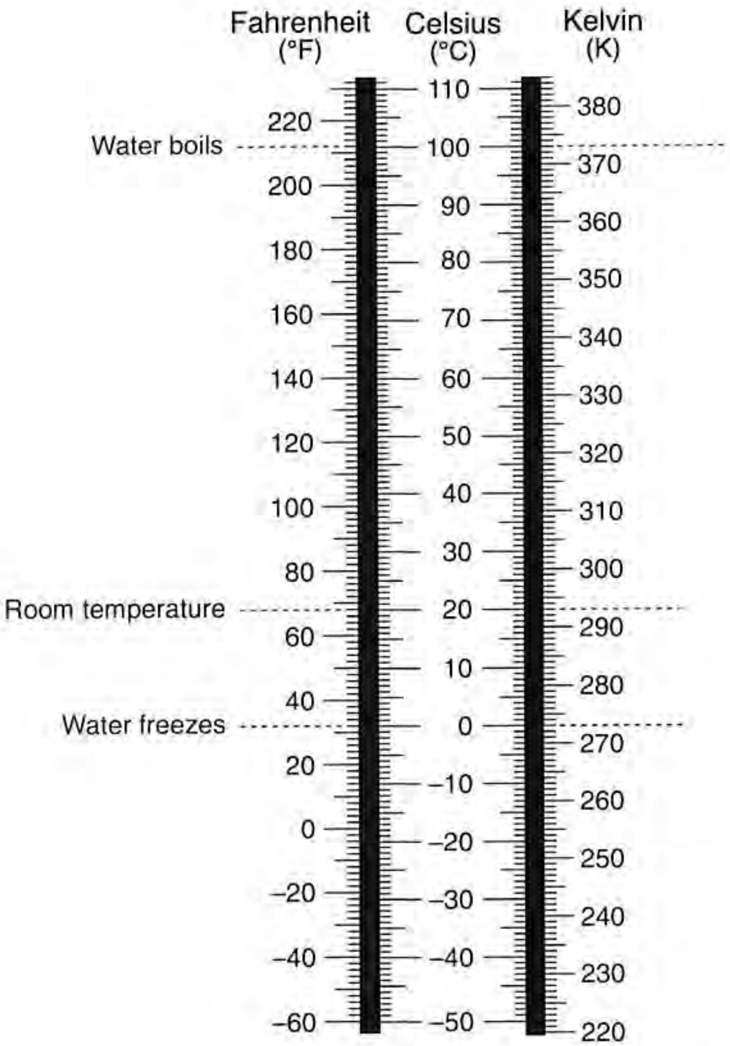
Dewpoint (°C)

Dry-Bulb Temperature (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (C°)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
−20	−20	−33														
−18	−18	−28														
−16	−16	−24														
−14	−14	−21	−36													
−12	−12	−18	−28													
−10	−10	−14	−22													
−8	−8	−12	−18	−29												
−6	−6	−10	−14	−22												
−4	−4	−7	−12	−17	−29											
−2	−2	−5	−8	−13	−20											
0	0	−3	−6	−9	−15	−24										
2	2	−1	−3	−6	−11	−17										
4	4	1	−1	−4	−7	−11	−19									
6	6	4	1	−1	−4	−7	−13	−21								
8	8	6	3	1	−2	−5	−9	−14								
10	10	8	6	4	1	−2	−5	−9	−14	−28						
12	12	10	8	6	4	1	−2	−5	−9	−16						
14	14	12	11	9	6	4	1	−2	−5	−10	−17					
16	16	14	13	11	9	7	4	1	−1	−6	−10	−17				
18	18	16	15	13	11	9	7	4	2	−2	−5	−10	−19			
20	20	19	17	15	14	12	10	7	4	2	−2	−5	−10	−19		
22	22	21	19	17	16	14	12	10	8	5	3	−1	−5	−10	−19	
24	24	23	21	20	18	16	14	12	10	8	6	2	−1	−5	−10	−18
26	26	25	23	22	20	18	17	15	13	11	9	6	3	0	−4	−9
28	28	27	25	24	22	21	19	17	16	14	11	9	7	4	1	−3
30	30	29	27	26	24	23	21	19	18	16	14	12	10	8	5	1

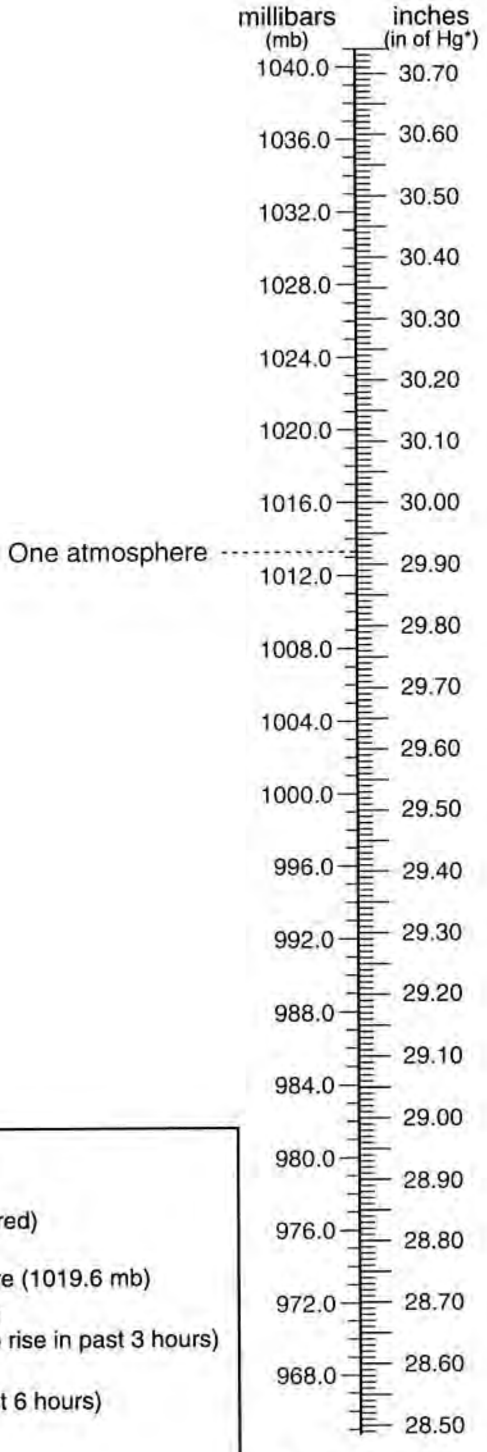
Relative Humidity (%)

Dry-Bulb Temperature (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (C°)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
−20	100	28														
−18	100	40														
−16	100	48														
−14	100	55	11													
−12	100	61	23													
−10	100	66	33													
−8	100	71	41	13												
−6	100	73	48	20												
−4	100	77	54	32	11											
−2	100	79	58	37	20	1										
0	100	81	63	45	28	11										
2	100	83	67	51	36	20	6									
4	100	85	70	56	42	27	14									
6	100	86	72	59	46	35	22	10								
8	100	87	74	62	51	39	28	17	6							
10	100	88	76	65	54	43	33	24	13	4						
12	100	88	78	67	57	48	38	28	19	10	2					
14	100	89	79	69	60	50	41	33	25	16	8	1				
16	100	90	80	71	62	54	45	37	29	21	14	7	1			
18	100	91	81	72	64	56	48	40	33	26	19	12	6			
20	100	91	82	74	66	58	51	44	36	30	23	17	11	5		
22	100	92	83	75	68	60	53	46	40	33	27	21	15	10	4	
24	100	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4
26	100	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9
28	100	93	86	78	71	65	59	53	47	42	36	31	26	21	17	12
30	100	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16

Temperature



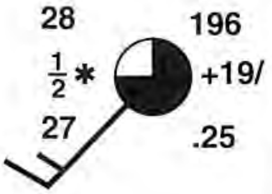
Pressure



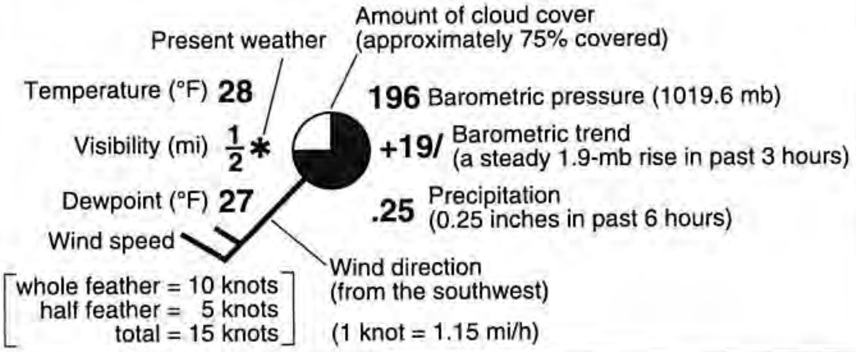
*Hg = mercury

Key to Weather Map Symbols

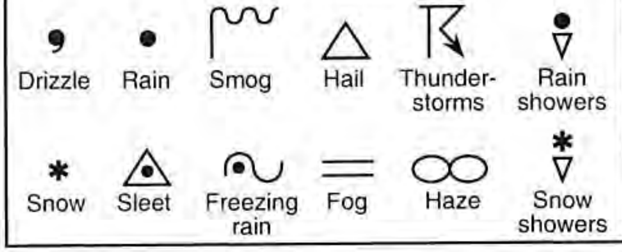
Station Model



Station Model Explanation



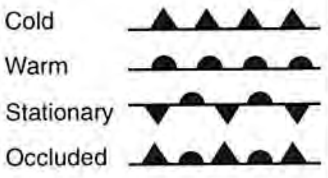
Present Weather



Air Masses

cA	continental arctic
cP	continental polar
cT	continental tropical
mT	maritime tropical
mP	maritime polar

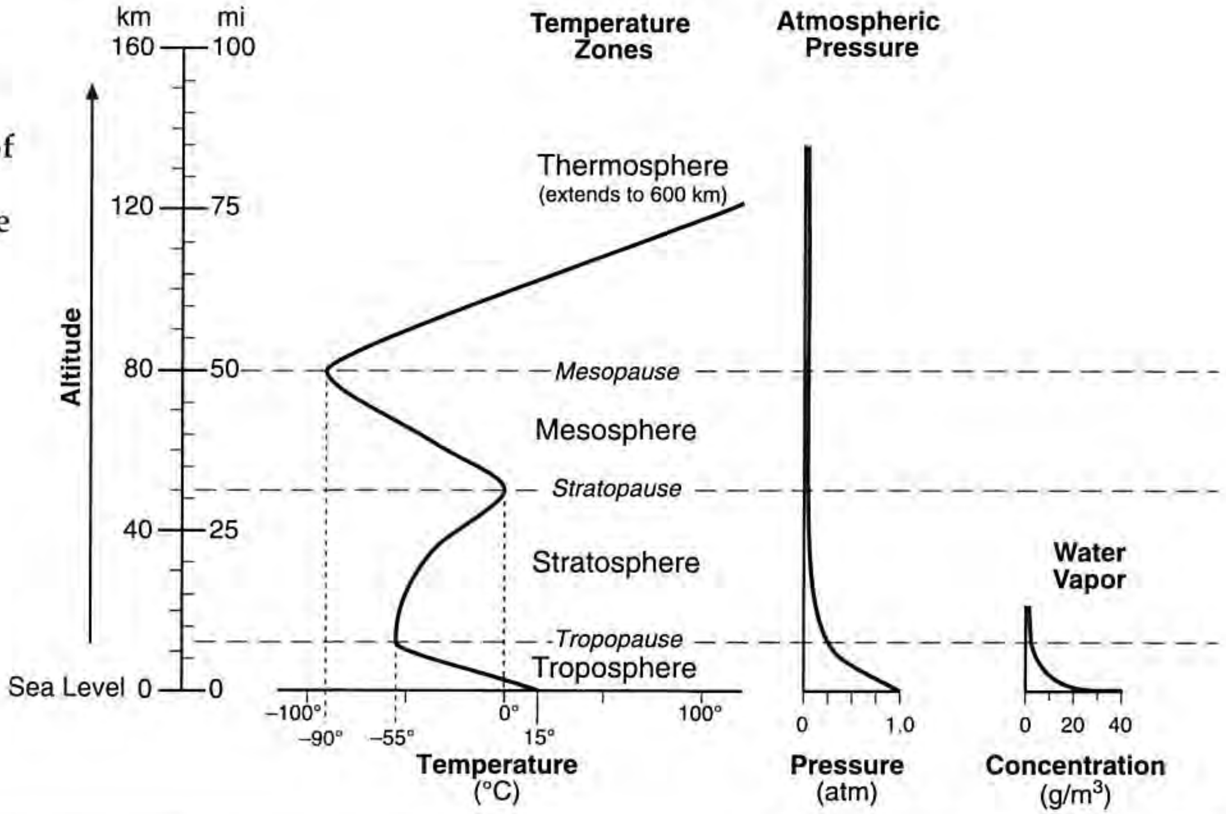
Fronts



Hurricane

Tornado

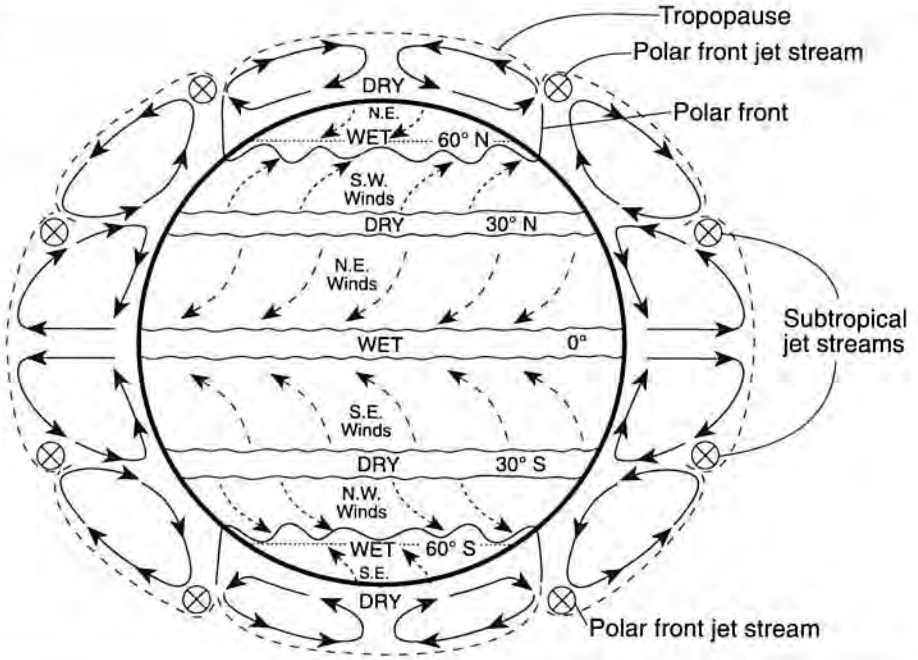
Selected Properties of Earth's Atmosphere



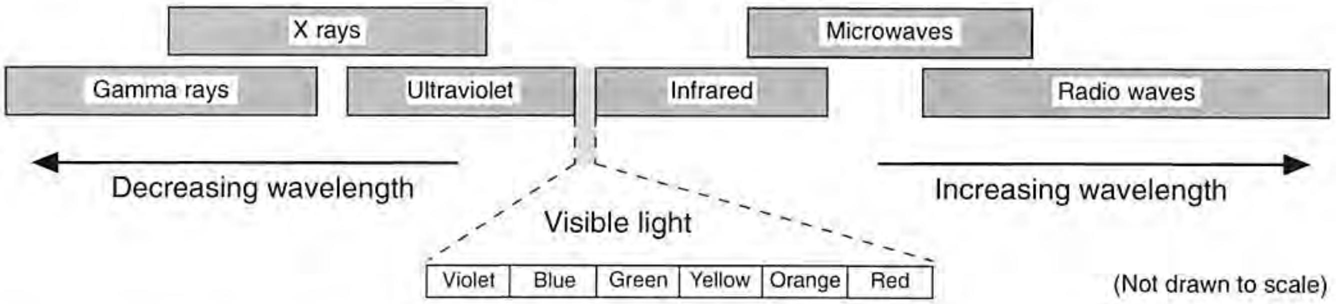
Planetary Wind and Moisture Belts in the Troposphere

The drawing on the right shows the locations of the belts near the time of an equinox. The locations shift somewhat with the changing latitude of the Sun's vertical ray. In the Northern Hemisphere, the belts shift northward in the summer and southward in the winter.

(Not drawn to scale)



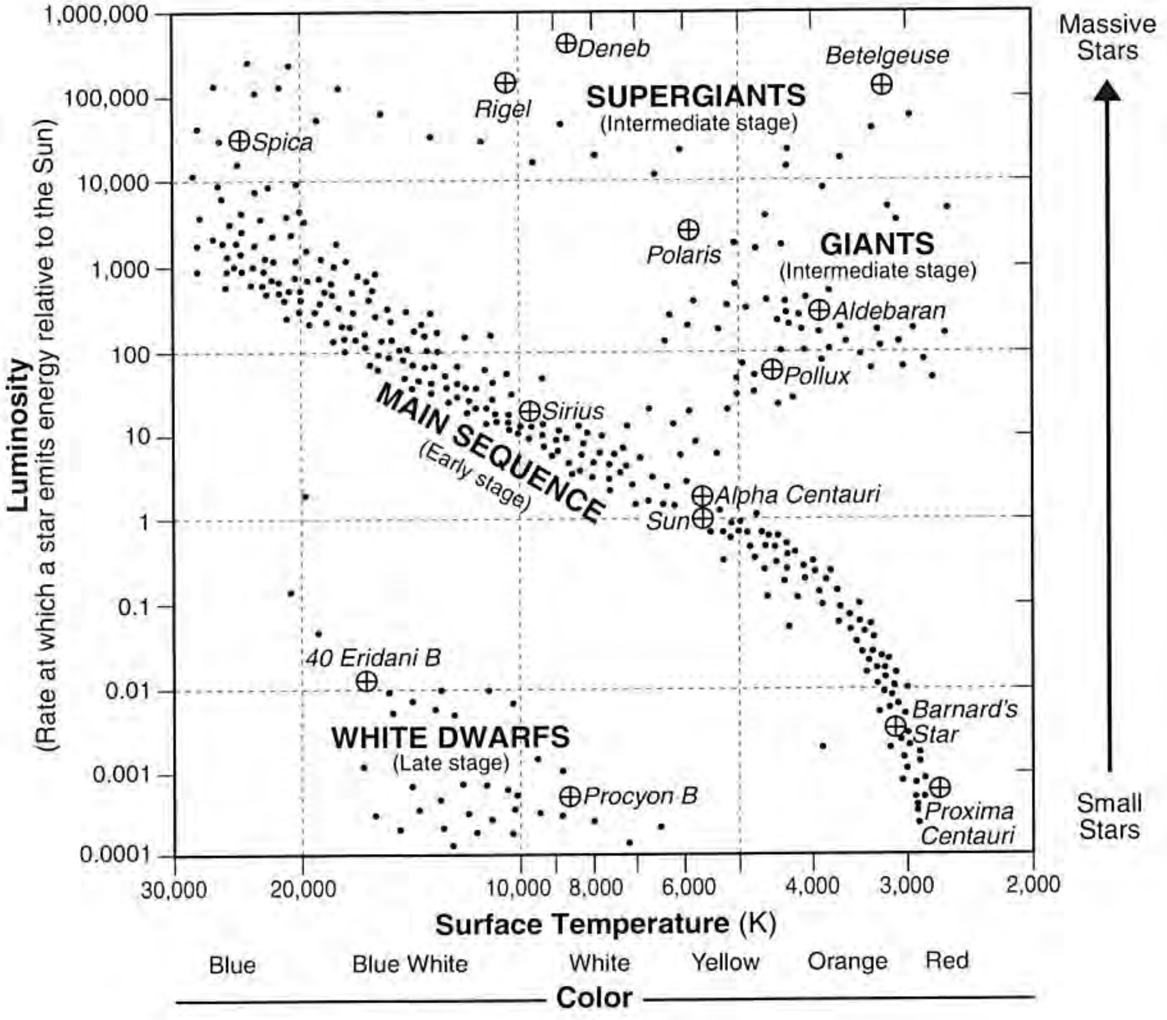
Electromagnetic Spectrum



(Not drawn to scale)

Characteristics of Stars

(Name in italics refers to star represented by a ⊕.)
(Stages indicate the general sequence of star development.)



Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)
SUN	—	—	27 d	—	1,392,000	333,000.00	1.4
MERCURY	57.9	88 d	59 d	0.206	4,879	0.06	5.4
VENUS	108.2	224.7 d	243 d	0.007	12,104	0.82	5.2
EARTH	149.6	365.26 d	23 h 56 min 4 s	0.017	12,756	1.00	5.5
MARS	227.9	687 d	24 h 37 min 23 s	0.093	6,794	0.11	3.9
JUPITER	778.4	11.9 y	9 h 50 min 30 s	0.048	142,984	317.83	1.3
SATURN	1,426.7	29.5 y	10 h 14 min	0.054	120,536	95.16	0.7
URANUS	2,871.0	84.0 y	17 h 14 min	0.047	51,118	14.54	1.3
NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

Properties of Common Minerals

LUSTER	HARD-NESS	CLEAVAGE	FRACTURE	COMMON COLORS	DISTINGUISHING CHARACTERISTICS	USE(S)	COMPOSITION*	MINERAL
Metallic luster	1–2	✓		silver to gray	black streak, greasy feel	pencil lead, lubricants	C	Grap
	2.5	✓		metallic silver	gray-black streak, cubic cleavage, density = 7.6 g/cm^3	ore of lead, batteries	PbS	Gale
	5.5–6.5		✓	black to silver	black streak, magnetic	ore of iron, steel	Fe_3O_4	Magn
	6.5		✓	brassy yellow	green-black streak, (fool's gold)	ore of sulfur	FeS_2	Pyr
Either	5.5 – 6.5 or 1		✓	metallic silver or earthy red	red-brown streak	ore of iron, jewelry	Fe_2O_3	Hema
Nonmetallic luster	1	✓		white to green	greasy feel	ceramics, paper	$Mg_3Si_4O_{10}(OH)_2$	Tal
	2		✓	yellow to amber	white-yellow streak	sulfuric acid	S	Sul
	2	✓		white to pink or gray	easily scratched by fingernail	plaster of paris, drywall	$CaSO_4 \cdot 2H_2O$	Selenite
	2–2.5	✓		colorless to yellow	flexible in thin sheets	paint, roofing	$KAl_3Si_3O_{10}(OH)_2$	Muscovi
	2.5	✓		colorless to white	cubic cleavage, salty taste	food additive, melts ice	NaCl	Hali
	2.5–3	✓		black to dark brown	flexible in thin sheets	construction materials	$K(Mg,Fe)_3$ $AlSi_3O_{10}(OH)_2$	Biotite
	3	✓		colorless or variable	bubbles with acid, rhombohedral cleavage	cement, lime	$CaCO_3$	Calc
	3.5	✓		colorless or variable	bubbles with acid when powdered	building stones	$CaMg(CO_3)_2$	Dolor
	4	✓		colorless or variable	cleaves in 4 directions	hydrofluoric acid	CaF_2	Fluo
	5–6	✓		black to dark green	cleaves in 2 directions at 90°	mineral collections, jewelry	$(Ca,Na)\ (Mg,Fe,Al)$ $(Si,Al)_2O_6$	Pyrox (commonl
	5.5	✓		black to dark green	cleaves at 56° and 124°	mineral collections, jewelry	$CaNa(Mg,Fe)_4\ (Al,Fe,Ti)_3$ $Si_6O_{22}(O,OH)_2$	Amphi (commonly h
	6	✓		white to pink	cleaves in 2 directions at 90°	ceramics, glass	$KAlSi_3O_8$	Potassium (commonly c
	6	✓		white to gray	cleaves in 2 directions, striations visible	ceramics, glass	$(Na,Ca)AlSi_3O_8$	Plagioclase
	6.5		✓	green to gray or brown	commonly light green and granular	furnace bricks, jewelry	$(Fe,Mg)_2SiO_4$	Olivi
	7		✓	colorless or variable	glassy luster, may form hexagonal crystals	glass, jewelry, electronics	SiO_2	Qua
	6.5–7.5		✓	dark red to green	often seen as red glassy grains in NYS metamorphic rocks	jewelry (NYS gem), abrasives	$Fe_3Al_2Si_3O_{12}$	Garr

*Chemical symbols:

Al = aluminum
C = carbon
Ca = calcium
Cl = chlorine
F = fluorine
Fe = iron
H = hydrogen
K = potassium
Mg = magnesium
Na = sodium
O = oxygen
Pb = lead
S = sulfur
Si = silicon
Ti = titanium

✓ = dominant form of breakage

C

THE UNIVERSITY OF THE STATE OF NEW YORK • THE STATE EDUCATION DEPARTMENT • ALBANY, NY 12234

Reference Tables for Physical Setting/CHEMISTRY

2011 Edition

Table A
Standard Temperature and Pressure

Name	Value	Unit
Standard Pressure	101.3 kPa 1 atm	kilopascal atmosphere
Standard Temperature	273 K 0°C	kelvin degree Celsius

Table B
Physical Constants for Water

Heat of Fusion	334 J/g
Heat of Vaporization	2260 J/g
Specific Heat Capacity of $H_2O(\ell)$	4.18 J/g•K

Table C
Selected Prefixes

Factor	Prefix	Symbol
10^{3}	kilo-	k
10^{-1}	deci-	d
10^{-2}	centi-	c
10^{-3}	milli-	m
10^{-6}	micro-	μ
10^{-9}	nano-	n
10^{-12}	pico-	p

Table D
Selected Units

Symbol	Name	Quantity
m	meter	length
g	gram	mass
Pa	pascal	pressure
K	kelvin	temperature
mol	mole	amount of substance
J	joule	energy, work, quantity of heat
s	second	time
min	minute	time
h	hour	time
d	day	time
y	year	time
L	liter	volume
ppm	parts per million	concentration
M	molarity	solution concentration
u	atomic mass unit	atomic mass

Table E
Selected Polyatomic Ions

Formula	Name
H_3O^+	hydronium
Hg_2^{2+}	mercury(I)
NH_4^+	ammonium
$\left.\begin{matrix} C_2H_3O_2^- \\ CH_3COO^- \end{matrix}\right\}$	acetate
CN^-	cyanide
CO_3^{2-}	carbonate
HCO_3^-	hydrogen carbonate
$C_2O_4^{2-}$	oxalate
ClO^-	hypochlorite
ClO_2^-	chlorite
ClO_3^-	chlorate
ClO_4^-	perchlorate

Formula	Name
CrO_4^{2-}	chromate
$Cr_2O_7^{2-}$	dichromate
MnO_4^-	permanganate
NO_2^-	nitrite
NO_3^-	nitrate
O_2^{2-}	peroxide
OH^-	hydroxide
PO_4^{3-}	phosphate
SCN^-	thiocyanate
SO_3^{2-}	sulfite
SO_4^{2-}	sulfate
HSO_4^-	hydrogen sulfate
$S_2O_3^{2-}$	thiosulfate

Table F
Solubility Guidelines for Aqueous Solutions

Ions That Form *Soluble* Compounds	Exceptions
Group 1 ions (Li^+, Na^+, etc.)	
ammonium (NH_4^+)	
nitrate (NO_3^-)	
acetate ($C_2H_3O_2^-$ or CH_3COO^-)	
hydrogen carbonate (HCO_3^-)	
chlorate (ClO_3^-)	
halides (Cl^-, Br^-, I^-)	when combined with Ag^+, Pb^{2+}, or Hg_2^{2+}
sulfates (SO_4^{2-})	when combined with Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, or Pb^{2+}

Ions That Form *Insoluble* Compounds*	Exceptions
carbonate (CO_3^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
chromate (CrO_4^{2-})	when combined with Group 1 ions, Ca^{2+}, Mg^{2+}, or ammonium (NH_4^+)
phosphate (PO_4^{3-})	when combined with Group 1 ions or ammonium (NH_4^+)
sulfide (S^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
hydroxide (OH^-)	when combined with Group 1 ions, Ca^{2+}, Ba^{2+}, Sr^{2+}, or ammonium (NH_4^+)

*compounds having very low solubility in H_2O

Table G
Solubility Curves at Standard Pressure

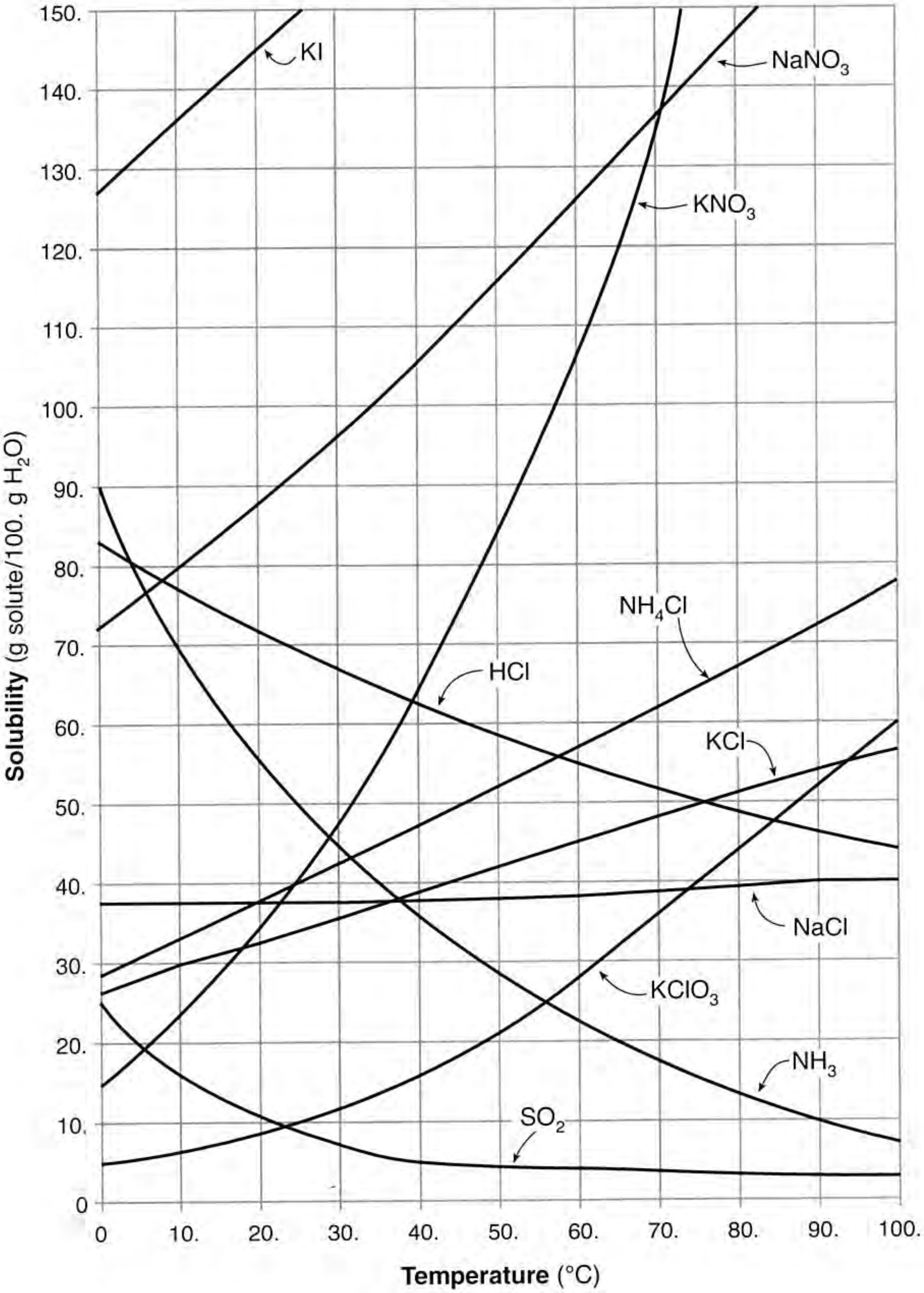


Table H
Vapor Pressure of Four Liquids

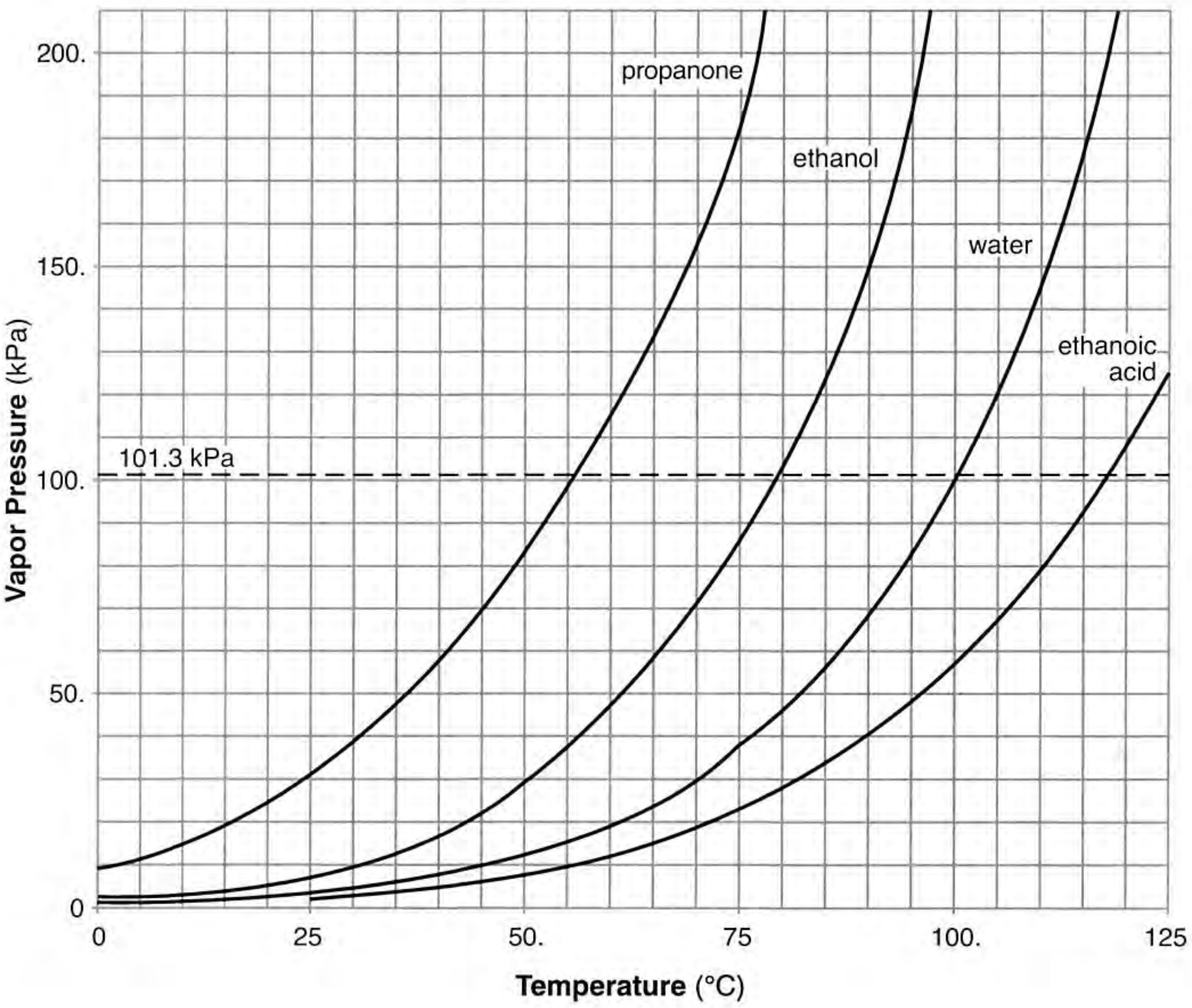


Table I
Heats of Reaction at 101.3 kPa and 298 K

Reaction	ΔH (kJ)*
$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(\ell)$	–890.4
$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(\ell)$	–2219.2
$2C_8H_{18}(\ell) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(\ell)$	–10943
$2CH_3OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(\ell)$	–1452
$C_2H_5OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(\ell)$	–1367
$C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(\ell)$	–2804
$2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$	–566.0
$C(s) + O_2(g) \longrightarrow CO_2(g)$	–393.5
$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$	–3351
$N_2(g) + O_2(g) \longrightarrow 2NO(g)$	+182.6
$N_2(g) + 2O_2(g) \longrightarrow 2NO_2(g)$	+66.4
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$	–483.6
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(\ell)$	–571.6
$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$	–91.8
$2C(s) + 3H_2(g) \longrightarrow C_2H_6(g)$	–84.0
$2C(s) + 2H_2(g) \longrightarrow C_2H_4(g)$	+52.4
$2C(s) + H_2(g) \longrightarrow C_2H_2(g)$	+227.4
$H_2(g) + I_2(g) \longrightarrow 2HI(g)$	+53.0
$KNO_3(s) \xrightarrow{H_2O} K^+(aq) + NO_3^-(aq)$	+34.89
$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$	–44.51
$NH_4Cl(s) \xrightarrow{H_2O} NH_4^+(aq) + Cl^-(aq)$	+14.78
$NH_4NO_3(s) \xrightarrow{H_2O} NH_4^+(aq) + NO_3^-(aq)$	+25.69
$NaCl(s) \xrightarrow{H_2O} Na^+(aq) + Cl^-(aq)$	+3.88
$LiBr(s) \xrightarrow{H_2O} Li^+(aq) + Br^-(aq)$	–48.83
$H^+(aq) + OH^-(aq) \longrightarrow H_2O(\ell)$	–55.8

*The ΔH values are based on molar quantities represented in the equations. A minus sign indicates an exothermic reaction.

Table J
Activity Series**

Most Active ↓

Metals	Nonmetals
Li	F_2
Rb	Cl_2
K	Br_2
Cs	I_2
Ba	
Sr	
Ca	
Na	
Mg	
Al	
Ti	
Mn	
Zn	
Cr	
Fe	
Co	
Ni	
Sn	
Pb	
H_2	
Cu	
Ag	
Au	

Least Active

**Activity Series is based on the hydrogen standard. H_2 is *not* a metal.

Table K
Common Acids

Formula	Name
$HCl(aq)$	hydrochloric acid
$HNO_2(aq)$	nitrous acid
$HNO_3(aq)$	nitric acid
$H_2SO_3(aq)$	sulfurous acid
$H_2SO_4(aq)$	sulfuric acid
$H_3PO_4(aq)$	phosphoric acid
$H_2CO_3(aq)$ or $CO_2(aq)$	carbonic acid
$CH_3COOH(aq)$ or $HC_2H_3O_2(aq)$	ethanoic acid (acetic acid)

Table L
Common Bases

Formula	Name
$NaOH(aq)$	sodium hydroxide
$KOH(aq)$	potassium hydroxide
$Ca(OH)_2(aq)$	calcium hydroxide
$NH_3(aq)$	aqueous ammonia

Table M
Common Acid–Base Indicators

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.1–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8–9	colorless to pink
litmus	4.5–8.3	red to blue
bromcresol green	3.8–5.4	yellow to blue
thymol blue	8.0–9.6	yellow to blue

Source: *The Merck Index*, 14th ed., 2006, Merck Publishing Group

Table N
Selected Radioisotopes

Nuclide	Half-Life	Decay Mode	Nuclide Name
^{198}Au	2.695 d	β^-	gold-198
^{14}C	5715 y	β^-	carbon-14
^{37}Ca	182 ms	β^+	calcium-37
^{60}Co	5.271 y	β^-	cobalt-60
^{137}Cs	30.2 y	β^-	cesium-137
^{53}Fe	8.51 min	β^+	iron-53
^{220}Fr	27.4 s	α	francium-220
^{3}H	12.31 y	β^-	hydrogen-3
^{131}I	8.021 d	β^-	iodine-131
^{37}K	1.23 s	β^+	potassium-37
^{42}K	12.36 h	β^-	potassium-42
^{85}Kr	10.73 y	β^-	krypton-85
^{16}N	7.13 s	β^-	nitrogen-16
^{19}Ne	17.22 s	β^+	neon-19
^{32}P	14.28 d	β^-	phosphorus-32
^{239}Pu	2.410×10^4 y	α	plutonium-239
^{226}Ra	1599 y	α	radium-226
^{222}Rn	3.823 d	α	radon-222
^{90}Sr	29.1 y	β^-	strontium-90
^{99}Tc	2.13×10^5 y	β^-	technetium-99
^{232}Th	1.40×10^{10} y	α	thorium-232
^{233}U	1.592×10^5 y	α	uranium-233
^{235}U	7.04×10^8 y	α	uranium-235
^{238}U	4.47×10^9 y	α	uranium-238

Source: *CRC Handbook of Chemistry and Physics*, 91st ed., 2010–2011, CRC Press

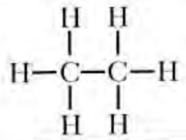
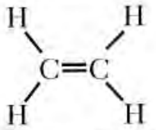
Table O
Symbols Used in Nuclear Chemistry

Name	Notation	Symbol
alpha particle	${}^{4}_{2}He$ or ${}^{4}_{2}\alpha$	α
beta particle	${}^{0}_{-1}e$ or ${}^{0}_{-1}\beta$	β^-
gamma radiation	${}^{0}_{0}\gamma$	γ
neutron	${}^{1}_{0}n$	n
proton	${}^{1}_{1}H$ or ${}^{1}_{1}p$	p
positron	${}^{0}_{+1}e$ or ${}^{0}_{+1}\beta$	β^+

Table P
Organic Prefixes

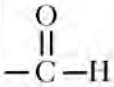
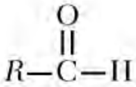
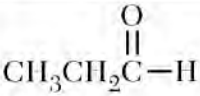
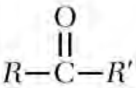
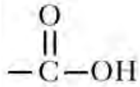
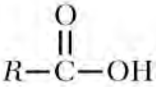
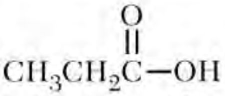
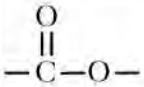
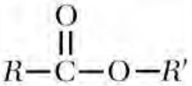
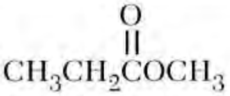
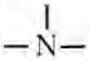
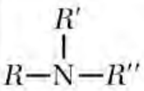
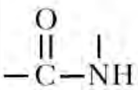
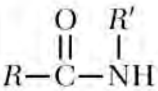
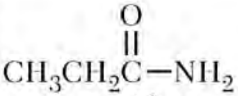
Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

Table Q
Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	C_nH_{2n+2}	ethane	
alkenes	C_nH_{2n}	ethene	
alkynes	C_nH_{2n-2}	ethyne	$H-C\equiv C-H$

Note: n = number of carbon atoms

Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	−F (fluoro-) −Cl (chloro-) −Br (bromo-) −I (iodo-)	$R-X$ (X represents any halogen)	$CH_3CHClCH_3$ 2-chloropropane
alcohol	$-OH$	$R-OH$	$CH_3CH_2CH_2OH$ 1-propanol
ether	$-O-$	$R-O-R'$	$CH_3OCH_2CH_3$ methyl ethyl ether
aldehyde	 $-\overset{O}{\overset{\|}{C}}-H$	 $R-\overset{O}{\overset{\|}{C}}-H$	 $CH_3CH_2\overset{O}{\overset{\|}{C}}-H$ propanal
ketone	 $-\overset{O}{\overset{\|}{C}}-$	 $R-\overset{O}{\overset{\|}{C}}-R'$	 $CH_3\overset{O}{\overset{\|}{C}}CH_2CH_2CH_3$ 2-pentanone
organic acid	 $-\overset{O}{\overset{\|}{C}}-OH$	 $R-\overset{O}{\overset{\|}{C}}-OH$	 $CH_3CH_2\overset{O}{\overset{\|}{C}}-OH$ propanoic acid
ester	 $-\overset{O}{\overset{\|}{C}}-O-$	 $R-\overset{O}{\overset{\|}{C}}-O-R'$	 $CH_3CH_2\overset{O}{\overset{\|}{C}}OCH_3$ methyl propanoate
amine	 $-\overset{\|}{N}-$	 $R-\overset{R'}{\overset{\|}{N}}-R''$	$CH_3CH_2CH_2NH_2$ 1-propanamine
amide	 $-\overset{O}{\overset{\|}{C}}-\overset{\|}{N}H$	 $R-\overset{O}{\overset{\|}{C}}-\overset{R'}{\overset{\|}{N}}H$	 $CH_3CH_2\overset{O}{\overset{\|}{C}}-NH_2$ propanamide

Note: R represents a bonded atom or group of atoms.

Periodic Table of the Elements

KEY

Atomic Mass → 12.011 −4 +2 +4 ← Selected Oxidation States
Symbol → **C**
Atomic Number → 6
Electron Configuration → 2-4

Relative atomic masses are based on ^{12}C = 12 (exact)

Note: Numbers in parentheses are mass numbers of the most stable or common isotope.

Period	Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1.00794 +1 −1 **H** 1 1																	4.00260 0 **He** 2 2
2	6.941 +1 **Li** 3 2-1	9.01218 +2 **Be** 4 2-2											10.81 +3 **B** 5 2-3	12.011 −4 +2 +4 **C** 6 2-4	14.0067 −3 −2 −1 +1 +2 +3 +4 +5 **N** 7 2-5	15.9994 −2 **O** 8 2-6	18.9984 −1 **F** 9 2-7	20.180 0 **Ne** 10 2-8
3	22.98977 +1 **Na** 11 2-8-1	24.305 +2 **Mg** 12 2-8-2											26.98154 +3 **Al** 13 2-8-3	28.0855 −4 +2 +4 **Si** 14 2-8-4	30.97376 −3 +3 +5 **P** 15 2-8-5	32.065 −2 +4 +6 **S** 16 2-8-6	35.453 −1 +1 +5 +7 **Cl** 17 2-8-7	39.948 0 **Ar** 18 2-8-8
4	39.0983 +1 **K** 19 2-8-8-1	40.08 +2 **Ca** 20 2-8-8-2	44.9559 +3 **Sc** 21 2-8-9-2	47.867 +2 +3 +4 **Ti** 22 2-8-10-2	50.9415 +2 +3 +4 +5 **V** 23 2-8-11-2	51.996 +2 +3 +6 **Cr** 24 2-8-13-1	54.9380 +2 +3 +4 +7 **Mn** 25 2-8-13-2	55.845 +2 +3 **Fe** 26 2-8-14-2	58.9332 +2 +3 **Co** 27 2-8-15-2	58.693 +2 +3 **Ni** 28 2-8-16-2	63.546 +1 +2 **Cu** 29 2-8-18-1	65.409 +2 **Zn** 30 2-8-18-2	69.723 +3 **Ga** 31 2-8-18-3	72.64 +2 +4 **Ge** 32 2-8-18-4	74.9216 −3 +3 +5 **As** 33 2-8-18-5	78.96 −2 +4 +6 **Se** 34 2-8-18-6	79.904 −1 +1 +5 **Br** 35 2-8-18-7	83.798 0 +2 **Kr** 36 2-8-18-8
5	85.4678 +1 **Rb** 37 2-8-18-8-1	87.62 +2 **Sr** 38 2-8-18-8-2	88.9059 +3 **Y** 39 2-8-18-9-2	91.224 +4 **Zr** 40 2-8-18-10-2	92.9064 +3 +5 **Nb** 41 2-8-18-12-1	95.94 +6 **Mo** 42 2-8-18-13-1	(98) +4 +6 +7 **Tc** 43 2-8-18-13-2	101.07 +3 **Ru** 44 2-8-18-15-1	102.906 +3 **Rh** 45 2-8-18-16-1	106.42 +2 +4 **Pd** 46 2-8-18-18	107.868 +1 **Ag** 47 2-8-18-18-1	112.41 +2 **Cd** 48 2-8-18-18-2	114.818 +3 **In** 49 2-8-18-18-3	118.71 +2 +4 **Sn** 50 2-8-18-18-4	121.760 −3 +3 +5 **Sb** 51 2-8-18-18-5	127.60 −2 +4 +6 **Te** 52 2-8-18-18-6	126.904 −1 +1 +5 +7 **I** 53 2-8-18-18-7	131.29 0 +2 +4 +6 **Xe** 54 2-8-18-18-8
6	132.905 +1 **Cs** 55 2-8-18-18-8-1	137.33 +2 **Ba** 56 2-8-18-18-8-2	138.9055 +3 **La** 57 2-8-18-18-9-2	178.49 +4 **Hf** 72 *18-32-10-2	180.948 +5 **Ta** 73 -18-32-11-2	183.84 +6 **W** 74 -18-32-12-2	186.207 +4 +6 +7 **Re** 75 -18-32-13-2	190.23 +3 +4 **Os** 76 -18-32-14-2	192.217 +3 +4 **Ir** 77 -18-32-15-2	195.08 +2 +4 **Pt** 78 -18-32-17-1	196.967 +1 +3 **Au** 79 -18-32-18-1	200.59 +1 +2 **Hg** 80 -18-32-18-2	204.383 +1 +3 **Tl** 81 -18-32-18-3	207.2 +2 +4 **Pb** 82 -18-32-18-4	208.980 +3 +5 **Bi** 83 -18-32-18-5	(209) +2 +4 **Po** 84 -18-32-18-6	(210) **At** 85 -18-32-18-7	(222) 0 **Rn** 86 -18-32-18-8
7	(223) +1 **Fr** 87 -18-32-18-8-1	(226) +2 **Ra** 88 -18-32-18-8-2	(227) +3 **Ac** 89 -18-32-18-9-2	(261) +4 **Rf** 104	(262) **Db** 105	(266) **Sg** 106	(272) **Bh** 107	(277) **Hs** 108	(276) **Mt** 109	(281) **Ds** 110	(280) **Rg** 111	(285) **Cn** 112	(284) **Uut** 113**	(289) **Uuq** 114	(288) **Uup** 115	(292) **Uuh** 116	(?) **Uus** 117	(294) **Uuo** 118

140.116 +3 +4 **Ce** 58	140.908 +3 **Pr** 59	144.24 +3 **Nd** 60	(145) +3 **Pm** 61	150.36 +2 +3 **Sm** 62	151.964 +2 +3 **Eu** 63	157.25 +3 **Gd** 64	158.925 +3 **Tb** 65	162.500 +3 **Dy** 66	164.930 +3 **Ho** 67	167.259 +3 **Er** 68	168.934 +3 **Tm** 69	173.04 +2 +3 **Yb** 70	174.9668 +3 **Lu** 71
232.038 +4 **Th** 90	231.036 +4 +5 **Pa** 91	238.029 +3 +4 +5 +6 **U** 92	(237) +3 +4 +5 +6 **Np** 93	(244) +3 +4 +5 +6 **Pu** 94	(243) +3 +4 +5 +6 **Am** 95	(247) +3 **Cm** 96	(247) +3 +4 **Bk** 97	(251) +3 **Cf** 98	(252) +3 **Es** 99	(257) +3 **Fm** 100	(258) +2 +3 **Md** 101	(259) +2 +3 **No** 102	(262) +3 **Lr** 103

*denotes the presence of (2-8-) for elements 72 and above

**The systematic names and symbols for elements of atomic numbers 113 and above will be used until the approval of trivial names by IUPAC.

Source: *CRC Handbook of Chemistry and Physics*, 91st ed., 2010–2011, CRC Press

Table S
Properties of Selected Elements

Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling* Point (K)	Density** (g/cm^3)	Atomic Radius (pm)
1	H	hydrogen	1312	2.2	14	20.	0.000082	32
2	He	helium	2372	—	—	4	0.000164	37
3	Li	lithium	520.	1.0	454	1615	0.534	130.
4	Be	beryllium	900.	1.6	1560.	2744	1.85	99
5	B	boron	801	2.0	2348	4273	2.34	84
6	C	carbon	1086	2.6	—	—	—	75
7	N	nitrogen	1402	3.0	63	77	0.001145	71
8	O	oxygen	1314	3.4	54	90.	0.001308	64
9	F	fluorine	1681	4.0	53	85	0.001553	60.
10	Ne	neon	2081	—	24	27	0.000825	62
11	Na	sodium	496	0.9	371	1156	0.97	160.
12	Mg	magnesium	738	1.3	923	1363	1.74	140.
13	Al	aluminum	578	1.6	933	2792	2.70	124
14	Si	silicon	787	1.9	1687	3538	2.3296	114
15	P	phosphorus (white)	1012	2.2	317	554	1.823	109
16	S	sulfur (monoclinic)	1000.	2.6	388	718	2.00	104
17	Cl	chlorine	1251	3.2	172	239	0.002898	100.
18	Ar	argon	1521	—	84	87	0.001633	101
19	K	potassium	419	0.8	337	1032	0.89	200.
20	Ca	calcium	590.	1.0	1115	1757	1.54	174
21	Sc	scandium	633	1.4	1814	3109	2.99	159
22	Ti	titanium	659	1.5	1941	3560.	4.506	148
23	V	vanadium	651	1.6	2183	3680.	6.0	144
24	Cr	chromium	653	1.7	2180.	2944	7.15	130.
25	Mn	manganese	717	1.6	1519	2334	7.3	129
26	Fe	iron	762	1.8	1811	3134	7.87	124
27	Co	cobalt	760.	1.9	1768	3200.	8.86	118
28	Ni	nickel	737	1.9	1728	3186	8.90	117
29	Cu	copper	745	1.9	1358	2835	8.96	122
30	Zn	zinc	906	1.7	693	1180.	7.134	120.
31	Ga	gallium	579	1.8	303	2477	5.91	123
32	Ge	germanium	762	2.0	1211	3106	5.3234	120.
33	As	arsenic (gray)	944	2.2	1090.	—	5.75	120.
34	Se	selenium (gray)	941	2.6	494	958	4.809	118
35	Br	bromine	1140.	3.0	266	332	3.1028	117
36	Kr	krypton	1351	—	116	120.	0.003425	116
37	Rb	rubidium	403	0.8	312	961	1.53	215
38	Sr	strontium	549	1.0	1050.	1655	2.64	190.
39	Y	yttrium	600.	1.2	1795	3618	4.47	176
40	Zr	zirconium	640.	1.3	2128	4682	6.52	164

Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling* Point (K)	Density** (g/cm^3)	Atomic Radius (pm)
41	Nb	niobium	652	1.6	2750.	5017	8.57	156
42	Mo	molybdenum	684	2.2	2896	4912	10.2	146
43	Tc	technetium	702	2.1	2430.	4538	11	138
44	Ru	ruthenium	710.	2.2	2606	4423	12.1	136
45	Rh	rhodium	720.	2.3	2237	3968	12.4	134
46	Pd	palladium	804	2.2	1828	3236	12.0	130.
47	Ag	silver	731	1.9	1235	2435	10.5	136
48	Cd	cadmium	868	1.7	594	1040.	8.69	140.
49	In	indium	558	1.8	430.	2345	7.31	142
50	Sn	tin (white)	709	2.0	505	2875	7.287	140.
51	Sb	antimony (gray)	831	2.1	904	1860.	6.68	140.
52	Te	tellurium	869	2.1	723	1261	6.232	137
53	I	iodine	1008	2.7	387	457	4.933	136
54	Xe	xenon	1170.	2.6	161	165	0.005366	136
55	Cs	cesium	376	0.8	302	944	1.873	238
56	Ba	barium	503	0.9	1000.	2170.	3.62	206
57	La	lanthanum	538	1.1	1193	3737	6.15	194
Elements 58–71 have been omitted.								
72	Hf	hafnium	659	1.3	2506	4876	13.3	164
73	Ta	tantalum	728	1.5	3290.	5731	16.4	158
74	W	tungsten	759	1.7	3695	5828	19.3	150.
75	Re	rhenium	756	1.9	3458	5869	20.8	141
76	Os	osmium	814	2.2	3306	5285	22.587	136
77	Ir	iridium	865	2.2	2719	4701	22.562	132
78	Pt	platinum	864	2.2	2041	4098	21.5	130.
79	Au	gold	890.	2.4	1337	3129	19.3	130.
80	Hg	mercury	1007	1.9	234	630.	13.5336	132
81	Tl	thallium	589	1.8	577	1746	11.8	144
82	Pb	lead	716	1.8	600.	2022	11.3	145
83	Bi	bismuth	703	1.9	544	1837	9.79	150.
84	Po	polonium	812	2.0	527	1235	9.20	142
85	At	astatine	—	2.2	575	—	—	148
86	Rn	radon	1037	—	202	211	0.009074	146
87	Fr	francium	393	0.7	300.	—	—	242
88	Ra	radium	509	0.9	969	—	5	211
89	Ac	actinium	499	1.1	1323	3471	10.	201
Elements 90 and above have been omitted.								

*boiling point at standard pressure

**density of solids and liquids at room temperature and density of gases at 298 K and 101.3 kPa

— no data available

Source: *CRC Handbook for Chemistry and Physics*, 91st ed., 2010–2011, CRC Press

Table T
Important Formulas and Equations

Density	$d = \frac{m}{V}$ d = density m = mass V = volume
Mole Calculations	number of moles = $\frac{\text{given mass}}{\text{gram-formula mass}}$
Percent Error	% error = $\frac{\text{measured value} - \text{accepted value}}{\text{accepted value}} \times 100$
Percent Composition	% composition by mass = $\frac{\text{mass of part}}{\text{mass of whole}} \times 100$
Concentration	parts per million = $\frac{\text{mass of solute}}{\text{mass of solution}} \times 1\,000\,000$
	molarity = $\frac{\text{moles of solute}}{\text{liter of solution}}$
Combined Gas Law	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ P = pressure V = volume T = temperature
Titration	$M_AV_A = M_BV_B$ M_A = molarity of H^+ M_B = molarity of OH^- V_A = volume of acid V_B = volume of base
Heat	$q = mC\Delta T$ $q = mH_f$ $q = mH_v$ q = heat m = mass C = specific heat capacity ΔT = change in temperature H_f = heat of fusion H_v = heat of vaporization
Temperature	K = °C + 273 K = kelvin °C = degree Celsius

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Reference Tables for Physical Setting/PHYSICS

2006 Edition

List of Physical Constants

Name	Symbol	Value
Universal gravitational constant	G	6.67×10^{-11} N•m^2/kg^2
Acceleration due to gravity	g	9.81 m/s^2
Speed of light in a vacuum	c	3.00×10^8 m/s
Speed of sound in air at STP		3.31×10^2 m/s
Mass of Earth		5.98×10^{24} kg
Mass of the Moon		7.35×10^{22} kg
Mean radius of Earth		6.37×10^6 m
Mean radius of the Moon		1.74×10^6 m
Mean distance—Earth to the Moon		3.84×10^8 m
Mean distance—Earth to the Sun		1.50×10^{11} m
Electrostatic constant	k	8.99×10^9 N•m^2/C^2
1 elementary charge	e	1.60×10^{-19} C
1 coulomb (C)		6.25×10^{18} elementary charges
1 electronvolt (eV)		1.60×10^{-19} J
Planck's constant	h	6.63×10^{-34} J•s
1 universal mass unit (u)		9.31×10^2 MeV
Rest mass of the electron	m_e	9.11×10^{-31} kg
Rest mass of the proton	m_p	1.67×10^{-27} kg
Rest mass of the neutron	m_n	1.67×10^{-27} kg

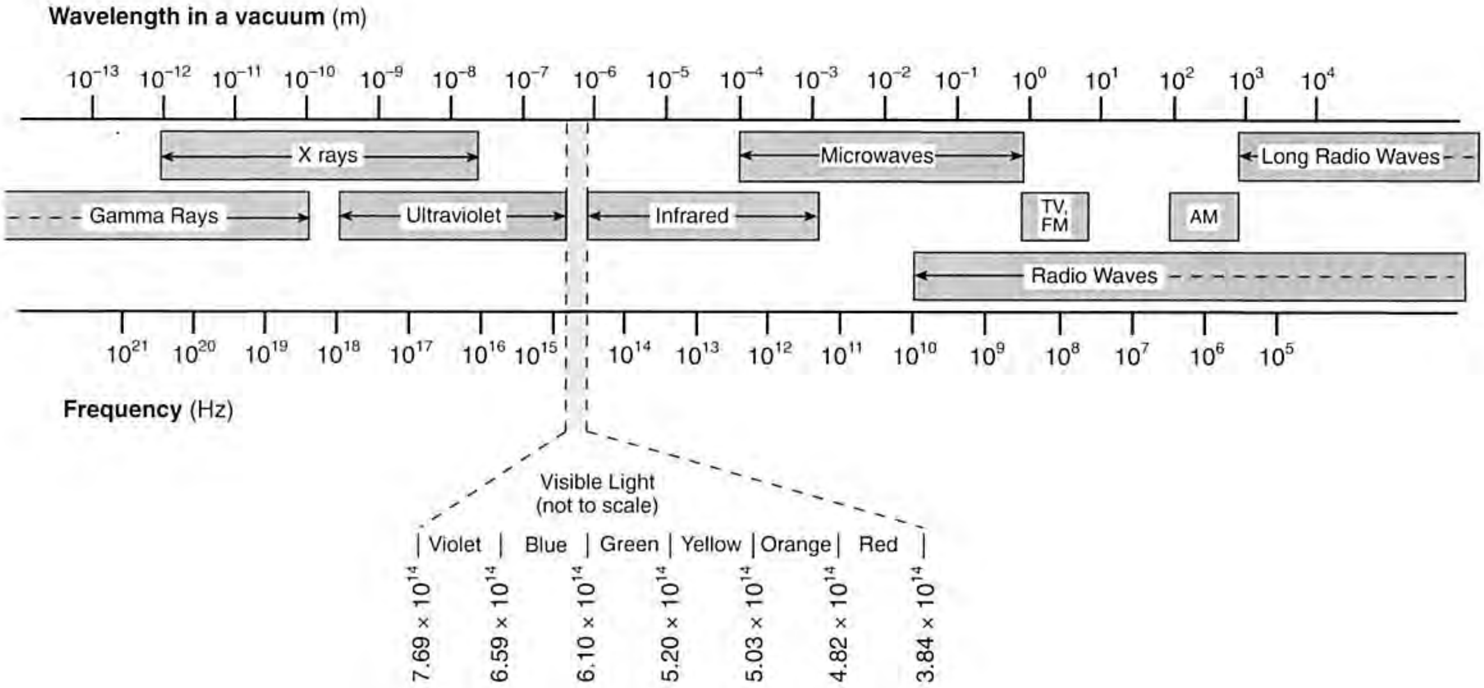
Prefixes for Powers of 10

Prefix	Symbol	Notation
tera	T	10^{12}
giga	G	10^9
mega	M	10^6
kilo	k	10^3
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

Approximate Coefficients of Friction

	Kinetic	Static
Rubber on concrete (dry)	0.68	0.90
Rubber on concrete (wet)	0.58	
Rubber on asphalt (dry)	0.67	0.85
Rubber on asphalt (wet)	0.53	
Rubber on ice	0.15	
Waxed ski on snow	0.05	0.14
Wood on wood	0.30	0.42
Steel on steel	0.57	0.74
Copper on steel	0.36	0.53
Teflon on Teflon	0.04	

The Electromagnetic Spectrum



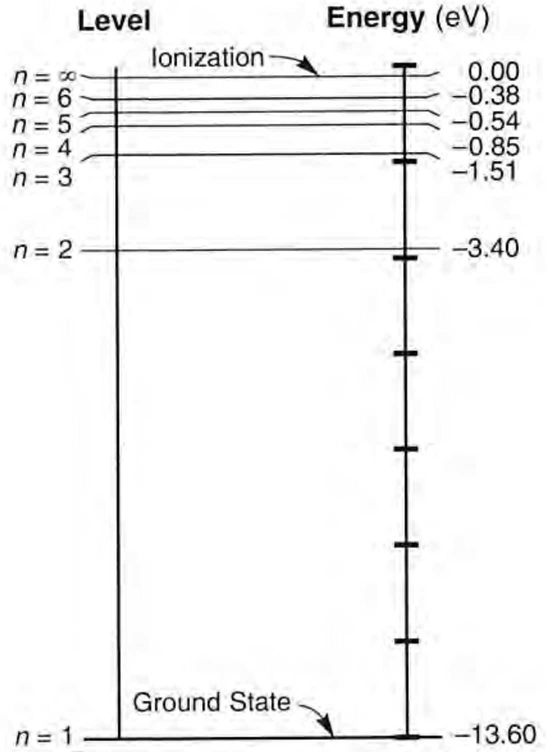
Absolute Indices of Refraction

($f = 5.09 \times 10^{14}$ Hz)

Air	1.00
Corn oil	1.47
Diamond	2.42
Ethyl alcohol	1.36
Glass, crown	1.52
Glass, flint	1.66
Glycerol	1.47
Lucite	1.50
Quartz, fused	1.46
Sodium chloride	1.54
Water	1.33
Zircon	1.92

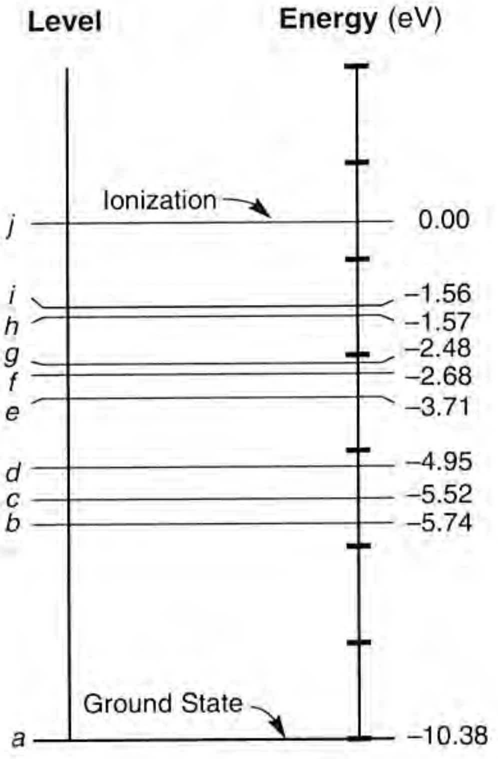
Energy Level Diagrams

Hydrogen



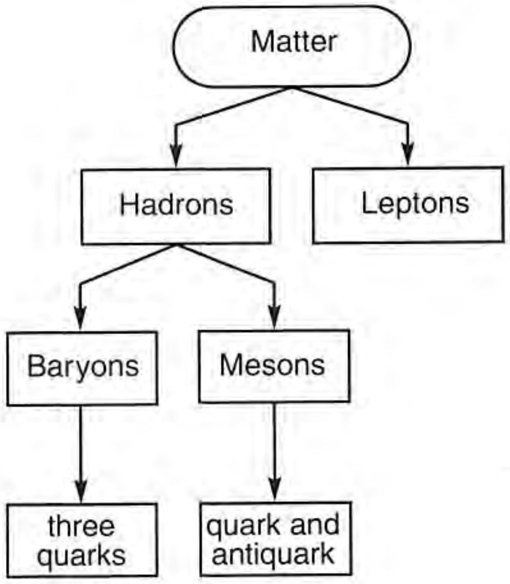
Energy Levels for the Hydrogen Atom

Mercury



A Few Energy Levels for the Mercury Atom

Classification of Matter



Particles of the Standard Model

Quarks

Name	up	charm	top
Symbol	u	c	t
Charge	$+\frac{2}{3}e$	$+\frac{2}{3}e$	$+\frac{2}{3}e$
	down	strange	bottom
	d	s	b
	$-\frac{1}{3}e$	$-\frac{1}{3}e$	$-\frac{1}{3}e$

Leptons

electron	muon	tau
e	μ	τ
−1e	−1e	−1e
electron neutrino	muon neutrino	tau neutrino
ν_e	ν_μ	ν_τ
0	0	0

Note: For each particle, there is a corresponding antiparticle with a charge opposite that of its associated particle.

Electricity

$$F_e = \frac{kq_1q_2}{r^2}$$

$$E = \frac{F_e}{q}$$

$$V = \frac{W}{q}$$

$$I = \frac{\Delta q}{t}$$

$$R = \frac{V}{I}$$

$$R = \frac{\rho L}{A}$$

$$P = VI = I^2R = \frac{V^2}{R}$$

$$W = Pt = VIt = I^2Rt = \frac{V^2t}{R}$$

A = cross-sectional area
E = electric field strength
F_e = electrostatic force
I = current
k = electrostatic constant
L = length of conductor
P = electrical power
q = charge
R = resistance
R_{eq} = equivalent resistance
r = distance between centers
t = time
V = potential difference
W = work (electrical energy)
Δ = change
ρ = resistivity

Series Circuits

$$I = I_1 = I_2 = I_3 = \ldots$$

$$V = V_1 + V_2 + V_3 + \ldots$$

$$R_{eq} = R_1 + R_2 + R_3 + \ldots$$

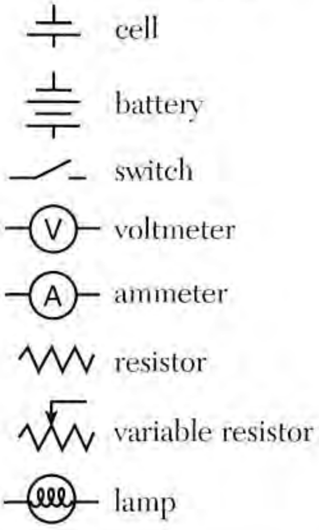
Parallel Circuits

$$I = I_1 + I_2 + I_3 + \ldots$$

$$V = V_1 = V_2 = V_3 = \ldots$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

Circuit Symbols



Resistivities at 20°C

Material	Resistivity (Ω•m)
Aluminum	2.82×10^{-8}
Copper	1.72×10^{-8}
Gold	2.44×10^{-8}
Nichrome	$150. \times 10^{-8}$
Silver	1.59×10^{-8}
Tungsten	5.60×10^{-8}

Waves

$v = f\lambda$

$T = \frac{1}{f}$

$\theta_i = \theta_r$

$n = \frac{c}{v}$

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

$\frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

c = speed of light in a vacuum
f = frequency
n = absolute index of refraction
T = period
v = velocity or speed
λ = wavelength
θ = angle
θ_i = angle of incidence
θ_r = angle of reflection

Modern Physics

$E_{photon} = hf = \frac{hc}{\lambda}$

$E_{photon} = E_i - E_f$

$E = mc^2$

c = speed of light in a vacuum
E = energy
f = frequency
h = Planck's constant
m = mass
λ = wavelength

Geometry and Trigonometry

Rectangle

$A = bh$

Triangle

$A = \frac{1}{2}bh$

Circle

$A = \pi r^2$

$C = 2\pi r$

Right Triangle

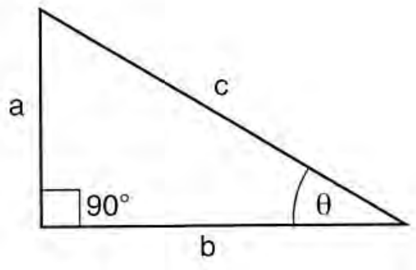
$c^2 = a^2 + b^2$

$\sin \theta = \frac{a}{c}$

$\cos \theta = \frac{b}{c}$

$\tan \theta = \frac{a}{b}$

A = area
b = base
C = circumference
h = height
r = radius



Mechanics

$$\overline{v} = \frac{d}{t}$$

$$a = \frac{\Delta v}{t}$$

$$v_f = v_i + at$$

$$d = v_i t + \frac{1}{2}at^2$$

$$v_f^2 = v_i^2 + 2ad$$

$$A_y = A \sin \theta$$

$$A_x = A \cos \theta$$

$$a = \frac{F_{net}}{m}$$

$$F_f = \mu F_N$$

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$g = \frac{F_g}{m}$$

$$p = mv$$

$$p_{before} = p_{after}$$

$$J = F_{net}t = \Delta p$$

$$F_s = kx$$

$$PE_s = \frac{1}{2}kx^2$$

$$F_c = ma_c$$

$$a_c = \frac{v^2}{r}$$

$$\Delta PE = mg\Delta h$$

$$KE = \frac{1}{2}mv^2$$

$$W = Fd = \Delta E_T$$

$$E_T = PE + KE + Q$$

$$P = \frac{W}{t} = \frac{Fd}{t} = F\overline{v}$$

a = acceleration

a_c = centripetal acceleration

A = any vector quantity

d = displacement or distance

E_T = total energy

F = force

F_c = centripetal force

F_f = force of friction

F_g = weight or force due to gravity

F_N = normal force

F_{net} = net force

F_s = force on a spring

g = acceleration due to gravity or gravitational field strength

G = universal gravitational constant

h = height

J = impulse

k = spring constant

KE = kinetic energy

m = mass

p = momentum

P = power

PE = potential energy

PE_s = potential energy stored in a spring

Q = internal energy

r = radius or distance between centers

t = time interval

v = velocity or speed

$\overline{v}$ = average velocity or average speed

W = work

x = change in spring length from the equilibrium position

Δ = change

θ = angle

μ = coefficient of friction

6-12

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NYC Science Scope & Sequence

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