NYC
Department of Education
Carmen Fariña, Chancellor

New York City

6-12 Science Scope & Sequence

2015–2016

NYC Department of Education

6-12 Science Scope & Sequence

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The New York City Department of Education

6–12 Science Scope & Sequence **2015–2016**

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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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.

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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.

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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.

- 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.

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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.

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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 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 simulation—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 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.	*[Refer to Appendix C – Reference Tables for Physical Setting/Earth Science]* Equations (p1) Average Chemical Composition of Earth's Crust, Hydrosphere, and Troposphere (p1) Generalized Landscape of Regions of New York State (p2) Generalized Bedrock Geology of New York State (p3) Tectonic Plates (p5) Rock Cycle in Earth's Crust (p6) Inferred Properties of Earth's Interior (p10) Earthquake P-Wave and S-Wave Travel Time (p11)

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.

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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

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■ 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*	**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.	**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

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- 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

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- 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.

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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.

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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

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

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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 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.	*[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
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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.
- 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

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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.

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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 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 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

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

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.

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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.
- Empirical evidence is needed to identify patterns.

continued

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■ 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*	**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.	**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*

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■ 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.

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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.

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

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.

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.
- Empirical evidence is needed to identify patterns.

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— 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*	**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.	**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*

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■ 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.

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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 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.	*[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

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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.

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NGSS CROSS-CUTTING CONCEPTS

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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.

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— 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	**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.
■ 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.		

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