Middle School Phenomenon Model Course 2 – Bundle 1
Transfer of Energy and Matter in Earth's Systems

This is the first bundle of the Middle School Phenomenon Model Course 2. Each bundle has connections to the other bundles in the course, as shown in the Course Flowchart.

Bundle 1 Question: This bundle is assembled to address the question "why do people live and farm on volcanoes?"

Summary

The bundle organizes performance expectations with a focus on helping students build understanding of the transfer of energy and matter between Earth Systems, including the biosphere. Instruction developed from this bundle should always maintain the three-dimensional nature of the standards, and recognize that instruction is not limited to the practices and concepts directly linked with any of the bundle performance expectations.

Connections between bundle DCIs

All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials (ESS2.A as in MS-ESS2-1). These ideas connect to the concept that the planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years (ESS2.A as in MS-ESS2-2). Many of these interactions involve the movement of water both on the land and underground which cause weathering and erosion, changing the land's surface features and creating underground formations (ESS2.C as in MS-ESS2-2).

The energy that flows and matter that cycles within Earth systems also produce chemical and physical changes in living organisms (ESS2.A as in MS-ESS2-1). Matter and energy are transferred between producers, consumers, and decomposers within an ecosystem, and the atoms that make up the matter are cycled repeatedly between the living and nonliving parts of an ecosystem (LS2.B as in MS-LS2-3). This idea connects to the concept that plants, algae, and many other microorganisms use the energy from light to make sugars from carbon dioxide and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use (LS1.C as in MS-LS1-6, PS3.D as in MS-LS1-6). Connecting to ideas about photosynthesis, food moves through a series of chemical reactions known as cellular respiration in which it is broken down and rearranged to form new molecules, to support growth, or to release energy within individual organisms (LS1.C as in MS-LS1-7, PS3.D as in MS-LS1-7).

Bundle Science and Engineering Practices

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the practices of developing models (MS-LS1-7, MS-LS2-3, and MS-ESS2-1) and constructing explanations (MS-LS1-6 and MS-ESS2-2). Many other practice elements can be used in instruction.

Bundle Crosscutting Concepts

Instruction leading to this bundle of PEs will help students build toward proficiency in elements of the crosscutting concepts of Scale, Proportion, and Quantity (MS-ESS2-2), Energy and Matter (MS-LS1-6, MS-LS1-7, and MS-LS2-3), and Stability and Change (MS-ESS2-1). Many other crosscutting concept elements can be used in instruction.

All instruction should be three-dimensional.

Performance Expectations	MS-LS1-6. **Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.** [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.] MS-LS1-7. **Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.** [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.] MS-LS2-3. **Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.** [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.] MS-ESS2-1. **Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.** [Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.] [Assessment Boundary: Assessment does not include the identification and naming of minerals.] MS-ESS2-2. **Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.** [Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.]
Example Phenomena	Sand from different beaches looks different. Some mushrooms grow on dead tree logs.
Additional Practices Building to the PEs	**Asking Questions and Defining Problems** • Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. Students could *ask questions that arise from careful observation of phenomena to seek additional information* [about how] ***the energy that flows and matter that cycles within and among the planet's systems produce chemical and physical changes in Earth's materials and living organisms***. MS-ESS2-1 **Developing and Using Models** • Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. Students could *develop and/or revise a model to show the relationships among* ***plants, photosynthesis, and sugars***. MS-LS1-6

Additional Practices Building to the PEs (Continued)	**Planning and Carrying Out Investigations** • 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. Students could *revise an experimental design to produce data to serve as the basis for evidence* [that] ***plants use the energy from light to make sugars from carbon dioxide from the atmosphere and water***. MS-LS1-6 **Analyzing and Interpreting Data** • Analyze and interpret data to provide evidence for phenomena. Students could *analyze and interpret data to provide evidence* [that] ***producers, consumers, and decomposers interact***. MS-LS2-3 **Using Mathematical and Computational Thinking** • Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems. Students could apply mathematical concepts [to show that] ***food webs demonstrate how matter and energy are transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem***. MS-LS2-3 **Constructing Explanations and Designing Solutions** • Construct an explanation using models or representations. Students could *construct an explanation using models or representations* [of how] ***all Earth processes are the result of energy flowing and matter cycling within and among the planet's systems***. MS-ESS2-1 **Engaging in Argument from Evidence** • 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. Students could *construct and present an oral argument supported by empirical evidence and scientific reasoning to refute an explanation* [for how] ***transfers of matter into and out of the physical environment occur at every level in a food web***. MS-LS2-3 **Obtaining, Evaluating, and Communicating Information** • 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. Students could *critically read scientific texts to obtain scientific information to describe evidence* [for how] ***within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy***. MS-LS1-7

Additional Crosscutting Concepts Building to the PEs	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. Students could construct an argument [for how] ***water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formation*** and [for how these] *cause and effect relationships may be used to predict phenomena in natural systems*. MS-ESS2-2 **Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Students could construct an argument that ***all Earth processes are the result of energy flowing and matter cycling within and among the planet's*** *systems and sub-systems* and [that] ***these systems range from microscopic to global in size, and they operate over fractions of a second to billions of years***. MS-ESS2-1 and MS-ESS2-2 **Energy and Matter** • Energy may take different forms (e.g. energy in fields, thermal energy, energy in motion). Students could ask questions [about how] *energy may take different forms* [when] ***flowing within and among the Earth's systems as it is derived from the sun and Earth's hot interior***. MS-ESS2-1
Additional Connections to Nature of Science	**Scientific Knowledge is Based on Empirical Evidence** • Science disciplines share common rules of obtaining and evaluating empirical evidence. Students could construct an argument supporting the claim that *science disciplines share common rules of obtaining and evaluating empirical evidence*, [using as evidence the way that biologists] *obtained and evaluated empirical evidence* [about how] ***within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy***. MS-LS1-7 **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science carefully considers and evaluates anomalies in data and evidence. Students could construct an argument about why *science carefully considers and evaluates anomalies in data and evidence*, [using as an example evidence for] ***how matter and energy are transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem***. MS-LS2-3

MS-LS1-6 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

MS-LS1-6. **Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.** [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [*Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.*]

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

Science and Engineering Practices

Constructing Explanations and Designing Solutions

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 knowledge, principles, and theories.

- 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.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based upon logical connections between evidence and explanations.

Disciplinary Core Ideas

LS1.C: Organization for Matter and Energy Flow in Organisms

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

PS3.D: Energy in Chemical Processes and Everyday Life

- The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. *(secondary)*

Crosscutting Concepts

Energy and Matter

- Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Observable features of the student performance by the end of the course:		
1	Articulating the explanation of phenomena	
	a	Students articulate a statement that relates the given phenomenon to a scientific idea, including the idea that photosynthesis results in the cycling of matter and energy into and out of organisms.
	b	Students use evidence and reasoning to construct a scientific explanation for the given phenomenon.
2	Evidence	
	a	Students identify and describe* evidence (e.g., from students' own investigations, observations, reading material, archived data) necessary to constructing the explanation, including that:
		i. Plants, algae, and photosynthetic microorganisms require energy (in the form of sunlight) and must take in carbon dioxide and water to survive.
		ii. Energy from sunlight is used to combine simple nonfood molecules (e.g., carbon dioxide and water) into food molecules (e.g., sugar) and oxygen, which can be used immediately or stored by the plant.
		iii. Animals take in food and oxygen to provide energy and materials for growth and survival.
		iv. Some animals eat plants, algae, and photosynthetic microorganisms, and some animals eat other animals, which have themselves eaten photosynthetic organisms.
	b	Students use multiple valid and reliable sources of evidence.

3	Reasoning	
	a	Students use reasoning, along with 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, to connect the evidence and support an explanation for energy and matter cycling during photosynthesis. Students describe* a chain of reasoning for their explanation, including:
		i. Plants, algae, and photosynthetic microorganisms take in matter (in the form of carbon dioxide and water) and use energy from the sun to produce carbon-based organic molecules (food), which they can use immediately or store, and release oxygen into the environment through photosynthesis.
		ii. Plants use the food they have made for energy, growth, and other necessary functions (e.g., repair, seed production).
		iii. Animals depend on matter from plants for growth and survival, including:
		1. Eating photosynthetic organisms (or other organisms that have eaten photosynthetic organisms), thus acquiring the matter they contain, the production of which was driven by photosynthesis.
		2. Breathing in oxygen, which was released when plants used energy to rearrange carbon dioxide and water during photosynthesis.
		iv. Because animals acquire their food from photosynthetic organisms (or from other animals that have eaten those organisms) and their oxygen from the products of photosynthesis, all food and most of the oxygen animals use for life processes are the results of energy from the sun driving matter flows through the process of photosynthesis.
		v. The process of photosynthesis has an important role in energy and matter cycling within plants (i.e., the conversion of carbon dioxide and water into complex carbon-based molecules (sugars) and oxygen, the contribution of sugars to plant growth and internal processes) as well as from plants to other organisms.

MS-LS1-7 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

MS-LS1-7. **Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.** [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [*Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.*]

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

Science and Engineering Practices

Developing and Using Models

Modeling in 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.

- Develop a model to describe unobservable mechanisms.

Disciplinary Core Ideas

LS1.C: Organization for Matter and Energy Flow in Organisms

- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

PS3.D: Energy in Chemical Processes and Everyday Life

- Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.*(secondary)*

Crosscutting Concepts

Energy and Matter

- Matter is conserved because atoms are conserved in physical and chemical processes.

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	To make sense of a phenomenon, students develop a model in which they identify the relevant components for describing* how food molecules are rearranged as matter moves through an organism, including:	
		i.	Molecules of food, which are complex carbon-containing molecules.
		ii.	Oxygen.
		iii.	Energy that is released or absorbed during chemical reactions between food and oxygen.
		iv.	New types of molecules produced through chemical reactions involving food.
2	Relationships		
	a	In the model, students identify and describe* the relationships between components, including:	
		i.	During cellular respiration, molecules of food undergo chemical reactions with oxygen, releasing stored energy.
		ii.	The atoms in food are rearranged through chemical reactions to form new molecules.
3	Connections		
	a	Students use the model to describe*:	
		i.	The number of each type of atom being the same before and after chemical reactions, indicating that the matter ingested as food is conserved as it moves through an organism to support growth.
		ii.	That all matter (atoms) used by the organism for growth comes from the products of the chemical reactions involving the matter taken in by the organism.
		iii.	Food molecules taken in by the organism are broken down and can then be rearranged to become the molecules that comprise the organism (e.g., the proteins and other molecules in a hamburger can be broken down and used to make a variety of tissues in humans).
		iv.	As food molecules are rearranged, energy is released and can be used to support other processes within the organism.

MS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-3. **Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.** [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [*Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.*]

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

Science and Engineering Practices

Developing and Using Models
Modeling in 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.

- Develop a model to describe phenomena.

Disciplinary Core Ideas

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

Crosscutting Concepts

Energy and Matter

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

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Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Observable features of the student performance by the end of the course:		
1	Components of the model	
	a	To make sense of a given phenomenon, students develop a model in which they identify the relevant components, including:
		i. Organisms that can be classified as producers, consumers, and/or decomposers.
		ii. Nonliving parts of an ecosystem (e.g., water, minerals, air) that can provide matter to living organisms or receive matter from living organisms.
		iii. Energy
	b	Students define the boundaries of the ecosystem under consideration in their model (e.g., pond, part of a forest, meadow; a whole forest, which contains a meadow, pond, and stream).
2	Relationships	
	a	In the model, students describe* relationships between components within the ecosystem, including:
		i. Energy transfer into and out of the system.
		ii. Energy transfer and matter cycling (cycling of atoms):
		1. Among producers, consumers, and decomposers (e.g., decomposers break down consumers and producers via chemical reactions and use the energy released from rearranging those molecules for growth and development).
		2. Between organisms and the nonliving parts of the system (e.g., producers use matter from the nonliving parts of the ecosystem and energy from the sun to produce food from nonfood materials).
3	Connections	
	a	Students use the model to describe* the cycling of matter and flow of energy among living and nonliving parts of the defined system, including:

		i. When organisms consume other organisms, there is a transfer of energy and a cycling of atoms that were originally captured from the nonliving parts of the ecosystem by producers.
		ii. The transfer of matter (atoms) and energy between living and nonliving parts of the ecosystem at every level within the system, which allows matter to cycle and energy to flow within and outside of the system.
	b	Students use the model to track energy transfer and matter cycling in the system based on consistent and measureable patterns, including:
		i. That the atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
		ii. That matter and energy are conserved through transfers within and outside of the ecosystem.

MS-ESS2-1 Earth's Systems

Students who demonstrate understanding can:

MS-ESS2-1. **Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.** [Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.] [*Assessment Boundary: Assessment does not include the identification and naming of minerals.*]

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

Science and Engineering Practices

Developing and Using Models

Modeling in 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.

- Develop and use a model to describe phenomena.

Disciplinary Core Ideas

ESS2.A: Earth's Materials and Systems

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

Crosscutting Concepts

Stability and Change

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.

Observable features of the student performance by the end of the course:		
1	Components of the model	
	a	To make sense of a given phenomenon, students develop a model in which they identify the relevant components, including:
		i. General types of Earth materials that can be found in different locations, including:
		1. Those located at the surface (exterior) and/or in the interior
		2. Those that exist(ed) before and/or after chemical and/or physical changes that occur during Earth processes (e.g., melting, sedimentation, weathering).
		ii. Energy from the sun.
		iii. Energy from the Earth's hot interior.
		iv. Relevant earth processes
		v. The temporal and spatial scales for the system.
2	Relationships	
	a	In the model, students describe* relationships between components, including:
		i. Different Earth processes (e.g., melting, sedimentation, crystallization) drive matter cycling (i.e., from one type of Earth material to another) through observable chemical and physical changes.
		ii. The movement of energy that originates from the Earth's hot interior and causes the cycling of matter through the Earth processes of melting, crystallization, and deformation.
		iii. Energy flows from the sun cause matter cycling via processes that produce weathering, erosion, and sedimentation (e.g., wind, rain).
		iv. The temporal and spatial scales over which the relevant Earth processes operate.
3	Connections	
	a	Students use the model to describe* (based on evidence for changes over time and processes at different scales) that energy from the Earth's interior and the sun drive Earth processes that together cause matter cycling through different forms of Earth materials.

	b	Students use the model to account for interactions between different Earth processes, including:
		i. The Earth's internal heat energy drives processes such as melting, crystallization, and deformation that change the atomic arrangement of elements in rocks and that move and push rock material to the Earth's surface where it is subject to surface processes like weathering and erosion.
		ii. Energy from the sun drives the movement of wind and water that causes the erosion, movement, and sedimentation of weathered Earth materials.
		iii. Given the right setting, any rock on Earth can be changed into a new type of rock by processes driven by the Earth's internal energy or by energy from the sun.
	c	Students describe* that these changes are consistently occurring but that landforms appear stable to humans because they are changing on time scales much longer than human lifetimes.

MS-ESS2-2 Earth's Systems

Students who demonstrate understanding can:

MS-ESS2-2. **Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.** [Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.]

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

Science and Engineering Practices

Constructing Explanations and Designing Solutions

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 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 nature operate today as they did in the past and will continue to do so in the future.

Disciplinary Core Ideas

ESS2.A: Earth's Materials and Systems

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

ESS2.C: The Roles of Water in Earth's Surface Processes

- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.

Crosscutting Concepts

Scale Proportion and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Observable features of the student performance by the end of the course:		
1	Articulating the explanation of phenomena	
	a	Students articulate a statement that relates a given phenomenon to a scientific idea, including that geoscience processes have changed the Earth's surface at varying time and spatial scales.
	b	Students use evidence and reasoning to construct an explanation for the given phenomenon, which involves changes at Earth's surface.
2	Evidence	
	a	Students identify and describe* the evidence necessary for constructing an explanation, including:
		i. The slow and large-scale motion of the Earth's plates and the results of that motion.
		ii. Surface weathering, erosion, movement, and the deposition of sediment ranging from large to microscopic scales (e.g., sediment consisting of boulders and microscopic grains of sand, raindrops dissolving microscopic amounts of minerals).
		iii. Rapid catastrophic events (e.g., earthquakes, volcanoes, meteor impacts).
	b	Students identify the corresponding timescales for each identified geoscience process.
	c	Students use multiple valid and reliable sources, which may include students' own investigations, evidence from data, and observations from conceptual models used to represent changes that occur on very large or small spatial and/or temporal scales (e.g., stream tables to illustrate erosion and deposition, maps and models to show the motion of tectonic plates).
	Reasoning	

3	a	Students use reasoning, along with 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, to connect the evidence and support an explanation for how geoscience processes have changed the Earth's surface at a variety of temporal and spatial scales. Students describe* the following chain of reasoning for their explanation:
		i. The motion of the Earth's plates produces changes on a planetary scale over a range of time periods from millions to billions of years. Evidence for the motion of plates can explain large-scale features of the Earth's surface (e.g., mountains, distribution of continents) and how they change.
		ii. Surface processes such as erosion, movement, weathering, and the deposition of sediment can modify surface features, such as mountains, or create new features, such as canyons. These processes can occur at spatial scales ranging from large to microscopic over time periods ranging from years to hundreds of millions of years.
		iii. Catastrophic changes can modify or create surface features over a very short period of time compared to other geoscience processes, and the results of those catastrophic changes are subject to further changes over time by processes that act on longer time scales (e.g., erosion of a meteor crater).
		iv. A given surface feature is the result of a broad range of geoscience processes occurring at different temporal and spatial scales.
		v. Surface features will continue to change in the future as geoscience processes continue to occur.