Grade 5 Science, Quarter 2, Unit 2.1

Force and Motion

Overview

Number of instructional days: 9 (1 day = 45 minutes)

Content to be learned

- Recognize that a force can be a push or pull.
- Explain that a force can cause changes in speed.
- Explain that a force can cause changes in direction of motion.
- Show that electric currents and magnets can exert forces on each other.
- Investigate how vibrations in materials set up wavelike disturbances that spread away from the source.

Science processes to be integrated

- Experiment, predict, and observe how forces interact with and change the behavior of objects within systems.
- Demonstrate and explain the effect of force on objects.

Essential questions

- Give a real-life example of a force applied to an object. How could the changes in the object's motion be described and explained?
- How do electric currents and magnets exert forces on each other?
- What effects can be observed when materials vibrate?

Written Curriculum

Grade-Span Expectations

PS 3 - The motion of an object is affected by forces.

PS3 (5-8) SAE+INQ – Local Assessment Only

Experiment, observe, or predict how energy might be transferred by means of waves.

PS3 (5-6) – LA Students demonstrate an understanding of waves by …

LAa investigate how vibrations in materials (e.g. pebble in a pond, jump rope, slinky) set up wavelike disturbances that spread away from the source.

PS3 (5-8) INQ+ POC –8

Use data to determine or predict the overall (net effect of multiple forces (e.g., friction, gravitational, magnetic) on the position, speed, and direction of motion of objects.

PS3 (5-6)–8 Students demonstrate an understanding of force (e.g., friction, gravitational, magnetic) by…

8b recognizing that a force is a push or a pull.

8c explaining that changes in speed or direction of motion are caused by forces.

8d showing that electric currents and magnets can exert a force on each other.

Clarifying the Standards

Prior Learning

In grades K–2, students demonstrated an understanding of motion by showing how pushing and pulling moves or does not move an object. They predicted the direction an object will or will not move when a force is applied to it. They demonstrated an understanding of force by showing that different objects fall to Earth unless something is holding them up. In addition, students demonstrated an understanding of magnetic force by observing and sorting objects that are and are not attracted to magnets.

In grades 3 and 4, students predicted the direction and described the motion of an object of different weights, shapes, or sizes when a force was applied. Students described the change in position relative to other objects or background and investigated and explained that different amounts of force can change direction and/or speed of an object in motion. Students conducted experiments to demonstrate that different objects fall to Earth unless something holds them up. Further, students demonstrated an understanding of magnetic force by using prior knowledge to predict and investigate whether an object will be attracted to a magnet. Students described what happens when like and opposite poles of a magnet are near each other, and they explored the relative strength of magnets (e.g., size of magnets, number of magnets, properties of materials).

Current Learning

In grade 5, students recognize that a force is a push or pull. Although the standards indicate that this concept is new, students have investigated the effects of pushes and pulls since kindergarten. Therefore, this concept should be taught at the drill-and-practice level of instruction. Fifth graders show that electric currents and magnets can exert a force on each other, and they investigate how vibrations in materials set up wavelike disturbances that spread away from the source. These concepts have not been addressed in prior grade levels and will not be addressed in subsequent grade levels; they should be taught at the developmental level to drill-and-practice level of instruction. Students also explain that forces cause changes in speed or direction. This is indicated in the standards to be a new concept; however, in grades 3 and 4, they investigated and explained that different amounts of force can change direction/speed of an object in motion. This concept should be taught at the reinforcement level of instruction.

To address the standards, students can conduct investigations in which they observe and describe the speed and direction of motion of marbles. For example, students can roll marbles across a variety of surfaces (e.g., tile, carpeting, tabletop). This gives students the opportunity to understand the affect of friction. Next, students can investigate the motion of marbles when rolled down a ramp. Students should vary the mass of the marble, height of the ramp, and height of the marble on the ramp. They should change only one variable at a time in order to determine the effect on the speed and motion of the marble. Students should place objects or barriers in the path of a marble to observe changes in speed and direction of the motion of the marble. The size and/or angle of the barrier can be changed. In each case, students identify and describe changes in speed and/or direction of the marble's motion.

Students need opportunities to observe waves that spread away when an object such as a pebble or marble is dropped into water (puddle, bucket) or when a force is exerted on a rope or slinky that is held at each end by two students. These experiences are foundational for understanding how energy is transferred by means of waves.

Prior to grade 5, students have not had experience with electromagnets. Therefore, they first need to build an electromagnet using a nail wrapped in wire and connected to a battery. Then, they need time to explore the properties of an electromagnet (e.g., Does an electromagnet have two poles? Does it have a magnetic field? Does it attract objects that contain iron?). Students can investigate the magnetic field by placing their electromagnet on a surface and moving a paperclip toward it until they detect a pull. This process is repeated all around the electromagnet until they have verified that a magnetic field surrounds the electromagnet. Students also need time to investigate the interactions that occur between an electromagnet and regular magnet (e.g., Do opposite poles attract? Do like poles repel?).

Future Learning

In grade 6, students will demonstrate an understanding of motion by using data or graphs to compare the relative speed of objects.

In grades 7 and 8, students will measure distance and time for a moving object and use those values as well as the relationship $s = d/t$ to calculate speed and graphically represent the data; they will solve for any unknown in the expression $s = d/t$ given values for the other two variables. Students will differentiate among speed, velocity, and acceleration and make and test predictions on how unbalanced forces acting on objects change speed or direction of motion or both. Students will explain or graphically represent that the acceleration of an object is proportional to the force on the object and inversely proportional to the object's mass, and they will differentiate between mass and weight.

Additional Findings

In grades 3–5, students continue to describe motion, and they can be more experimental and quantitative as their measurement skills sharpen. Determining the speed of fast things and slow things can present a challenge to which students readily respond. They also can work out for themselves some general relationships between force and change of motion and internalize the notion of force as a push or pull of one thing on another. By the end of grade 5, students should know that changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion; the more massive an object is, the less effect a given force has. (*Benchmarks for Science Literacy*, p. 89)

In grades 5–8, the study of motion and the forces causing motion provide concrete experiences on which a more comprehensive understanding of force can be based in grades 9–12. By using simple objects such as rolling balls and mechanical toys, students can move from qualitative to quantitative descriptions of moving objects and begin to describe the forces acting on the objects. Students' everyday experience is that friction causes all moving objects to slow down and stop. Through experiences in which friction is reduced, students can begin to see that a moving object with no friction continues to move indefinitely; however, most students believe that the force is still acting if the object is moving or that it is "used up" if the motion stops. Students also think that friction, not inertia, is the principal reason objects remain at rest or require a force to move. They associate force with motion and have difficulty understanding balanced forces in equilibrium, especially if the force is associated with static, inanimate objects such as a book resting on the desk. (*National Science Education Standards*, pp. 149 and 154)

Students tend to think of force as a property of an object (i.e., "An object has force." or "Force is within an object.") rather than as a relation between objects. In addition, students usually distinguish between active objects and those that support, block, or otherwise act passively. Students tend to call the active actions *force*, but do not consider passive actions as forces. Teaching students to integrate the concept of passive support into the broader concept of force is a challenging task, even at the high school level. (*Benchmarks for Science Literacy*, p. 339)

Students believe constant speed needs some cause to be sustained. In addition, they believe that the amount of motion is proportional to the amount of force, that if a body is not moving there is no force acting on it, and that if a body is moving there is a force acting on it in the direction of the motion. Students also believe that objects resist acceleration from the state of rest because of friction—that is, they confound inertia with friction. (*Benchmarks for Science Literacy*, p. 339).

Students have difficulty appreciating that all interactions involve equal forces acting in opposite directions on separate, interacting bodies. Instead students believe that "active" objects (e.g., hands) can exert forces whereas "passive" objects (e.g., tables) cannot. Alternatively, students may believe that the object with more of some obvious property will exert a greater force. (*Benchmarks for Science Literacy*, p. 339)

Grade 5 Science, Quarter 2, Unit 2.2

Space Science

Overview

Number of instructional days: 12 (1 day = 45 minutes)

Content to be learned

- Use data to identify and compare the size, location, and distance of planets in the solar system.
- Use data to identify and compare the movements of objects in our solar system (e.g., orbits of planets, paths of meteors).
- Use data to compare the composition, atmosphere, and surface features of objects in our solar system.
- Describe the apparent motion and position of objects (e.g., constellations, planets) in the sky.
- Explain how night and day are the result of the regular and predictable motion of Earth.
- Explain how a year is the result of the regular and predictable motion of Earth around the sun.

Science processes to be integrated

- Collect, record, and analyze data to identify and compare the size, location, distance, and motion of objects.
- Collect, record, and analyze data to compare and contrast the characteristics of objects.
- Create and use models to understand and explain the relationships within a system.
- Use models to observe and explain regular and predictable changes in motion over time.

Essential questions

- How do the size, location, and distances among planets in the solar system compare?
- How can the general characteristics of objects in our solar system, such as the composition, atmosphere, and surface features, be described?
- How do the paths of planets and meteors compare?
- What cycles of change are caused by the predictable motion of Earth?

Written Curriculum

Grade-Span Expectations

ESS2 - The earth is part of a solar system, made up of distinct parts that have temporal and spatial interrelationships.

ESS2 (5-8) SAE+ POC –8

Explain temporal or positional relationships between or among the Earth, sun, and moon (e.g., night/day, seasons, year, tides) or how gravitational force affects objects in the solar system (e.g., moons, tides, orbits, satellites).

ESS2 (7-8)–8 Students demonstrate an understanding of temporal or positional relationships between or among the Earth, sun, and moon by …

8b explaining night/day, ~~seasons,~~ years~~, and tides~~ as a result of the regular and predictable motion of the Earth, sun, and moon.

ESS3 - The origin and evolution of galaxies and the universe demonstrate fundamental principles of physical science across vast distances and time

No further targets for EK ESS3 at the 5-8 Grade Span

The GSEs listed below are assessed at the local level only

ESS3 (5-6)–9 Students demonstrate an understanding of the structure of the universe by …

9a describing the apparent motion/position of the objects in the sky. (e.g. constellations, planets).

ESS2 - The earth is part of a solar system, made up of distinct parts that have temporal and spatial interrelationships.

ESS2 (5-8) MAS –6

Compare and contrast planets based on data provided about size, composition, location, orbital movement, atmosphere, or surface features (includes moons).

ESS2 (5-6)-6 Students demonstrate an understanding of characteristics of the solar system by …

6a identifying and comparing the size, location, distances, and movement (e.g. orbit of planets, path of meteors) of the objects in our solar system.

6b comparing the composition, atmosphere, and surface features of objects in our solar system.

Clarifying the Standards

Prior Learning

In grades K–2, students observed that the sun can only be seen in the daytime, but the moon can be seen sometimes at night and sometimes during the day. They observed that the sun and moon appear to move slowly across the sky and that the moon looks slightly different from day to day. Students also observed that there are more stars in the sky than can easily be counted, but they are not scattered evenly and are not all the same in brightness.

In grades 3 and 4, students observed that the sun, moon, and stars appear to move slowly across the sky and that the moon looks slightly different from day to day, but it looks the same again in about four weeks. They recognized that the rotation of Earth on its axis every 24 hours produces the day/night cycle. Students demonstrated an understanding of characteristics of the solar system by recognizing that the sun is the center of the solar system, Earth is one of several planets that orbit the sun, and the moon orbits Earth. They recognized that it takes approximately 365 days for Earth to orbit the sun. Students also recognized that throughout history people have identified patterns of stars called *constellations*.

Current Learning

Students have observed the sun, moon, and stars since kindergarten. Students have observed the apparent movement of the sun, moon, and stars, and they have observed cyclical changes to the appearance of the moon. They have learned that the sun is the center of our solar system, that patterns of stars are called *constellations*, and that the movement of Earth causes a 24-hour day/night cycle as well as a 365-day year. Therefore, at the reinforcement level of instruction, students explain the day/night cycle and the 365-day year as a result of the regular and predictable motion of Earth and describe the apparent motion/position of objects in the solar system. Using data to identify and compare size, location, distance, and movement of planets and comparing the composition, atmosphere, and surface features of planets and other objects in our solar system are new concepts and should be taught at the developmental level to reinforcement level of instruction.

Throughout this unit, models and simulations should be used to help students develop a conceptual understanding of the abstract concepts found in space science. Comprehending the immense sizes of the moon, planets, sun, and other stars and the vast distances between them requires careful consideration of the types of models used with students. In the classroom, fifth graders should build, observe, and study multiple two- and three-dimensional models and should be given the opportunity to discuss the limitations of each. Teachers should also take the time to use models that incorporate accurate scale (both size and distance) in order for students to understand the immense size of the solar system. In addition, students could create star maps or a planisphere (www.vcas.org/star-wheels.html) to develop an understanding of constellations and how the movement of Earth over a year affects your view of the night sky.

To develop an understanding of an orbit, students can kinesthetically model an orbit. Loosely tie the ends of a string around the waists of two students, and then have the students move, rotating and revolving, as appropriate. Explain to students that in this model, the string represents the force of gravity that holds planets and moons in orbit. When modeling the movement (rotation and revolution) of Earth around the sun, one student remains stationary (the sun), while the other (Earth) rotates and revolves around him/her. When modeling the movement (rotation and revolution) of the moon around Earth, one student (Earth) rotates but remains in the same spot, which simulates the motion of Earth. The other student rotates *slowly* and revolves, which simulates the motion of the moon. It is important for students to see and

understand that the moon rotates, but at a much slower rate than the rotation of Earth. The moon rotates on its axis only once in approximately 27.3 days, while Earth rotates in 24 hours. Therefore, the student who is modeling the movement of the moon should rotate so that he/she "faces" Earth at all times. It is recommended that teachers also use online simulations as well as three-dimensional models to show the relationships within the sun, Earth, and moon system.

There are a number of sources available on the Internet that can be used to help develop student understanding of the characteristics of the planets in our solar system. However, many of these sites contain more information than is necessary for grade 5. Students can use some of this information to create either two- or 3-dimensional models of planets in the solar system. Students should develop an understanding of the location of each planet relative to the sun. Given data from resources such as books, student magazines, and reliable websites (e.g., NASA or Discovery Education), students can compare and contrast the composition and surface features of planets and their atmospheres as well as other information such as the number of moons. Students could use some of this information to classify planets by these characteristics (e.g., inner terrestrial versus outer gas giants). The movement of other celestial bodies such as asteroids, meteors, and comets can also be introduced using information from the aforementioned resources.

Future Learning

In grade 6, students will use models to describe the relative motion/position of the Earth, sun, and moon, and they will use a model of the Earth, sun, and moon to recreate the phases of the moon. They will explain seasons and tides as a result of the regular and predictable motion of the Earth, sun, and moon. Students will define Earth's gravity as a force that pulls any object on or near Earth toward its center without touching it and will identify the sun as a medium-sized star located near the edge of a disc-shaped galaxy of stars.

In grades 7 and 8, students will demonstrate an understanding of how technological advances have allowed scientists to reevaluate or extend existing ideas about the solar system by identifying major discoveries from different scientists and cultures and describing how these discoveries have contributed to your understanding of the solar system (e.g., timeline, research project, picture book). Further, students in grades 7 and 8 will use or create a model of the Earth, sun, and moon system to show revolution and rotation. Students will explain night/day, seasons, year, and tides as a result of the regular and predictable motion of the Earth, sun, and moon, and they will use a model of the Earth, sun, and moon to recreate the phases of the moon. Students will demonstrate an understanding of gravitational relationships by describing the relationship between mass and the gravitational force between objects. They will describe the relationship between distance and the gravitational force between objects and will explain that the sun's gravitational pull holds Earth and other planets in their orbits just as the planets' gravitational pull keeps their moons in orbit. Students will also demonstrate an understanding of the structure of the universe by describing the universe as containing many billions of galaxies and each galaxy containing many billions of stars.

Additional Findings

In grades 3–5, students should begin to develop an inventory of the variety of things in the universe. Planets can be shown to be different from stars in two essential ways—their appearance and motion. When a modest telescope or pair of binoculars is used instead of the naked eyes, stars only look brighter—and more of them can be seen. The brighter planets, however, clearly are disks (not very large disks, except in good-sized telescopes, but impressive enough after seeing a lot of stars). The fixed patterns of stars should be made more explicit, although learning the constellation names is not important in itself. When students know that the star patterns stay the same as they move across the sky (and gradually shift with the seasons), they can then observe that the planets change their position against the pattern of stars. (*Benchmarks for Science Literacy*, p. 62)

Students can also learn some of Earth's relation to the sun, moon, and other planets. Films, computer simulations, planetariums, and telescopic observations help. It is essential that all students, sometimes working in small groups, make physical models and explain what the models show. At the same time, students can begin learning about scale (counting, comparative distances, volumes, times, etc.) in readily understood activities and readings that interest them. However, scale factors larger than thousands, and even the idea of ratios, may be difficult before students reach early adolescence. (*Benchmarks for Science Literacy*, p. 67)

An important point to be made along the way is that you cannot determine how the solar system is put together just by looking at it. Diagrams show what the solar system would look like if people could see it from far away (a feat that cannot be accomplished). Telescopes and other instruments provide information, but models are needed to make sense out of the information. In making diagrams to show the relative sizes of the planets and the distances of the planets from the sun, students may try to combine them using a single scale—and quickly become frustrated. Perhaps this frustration can lead to a discussion of the general limits of graphic methods (including models and photographs) for showing reality. In any case, at this stage a rough picture of the organization of the solar system is enough. (*Benchmarks for Science Literacy*, p. 67)

By the end of grade 5, students should know that the patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons. Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light. Planets change their positions against the background of stars, Earth is one of several planets that orbit the sun, and the moon orbits Earth (*Benchmarks for Science Literacy*, p. 63). Like all planets and stars, Earth is approximately spherical in shape. The rotation of Earth on its axis every 24 hours produces the day/night cycle. To people on Earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting Earth once a day. (*Benchmarks for Science Literacy*, p. 68)

The ideas that "the sun is a star" and "Earth orbits the sun" appear counterintuitive to elementary school students. These ideas are not likely to be believed or even understood in elementary grades. Even if it is possible for elementary students to understand, these concepts, even with good teaching, need further investigation. Student ideas about the shape of Earth are closely related to their ideas about gravity and the direction of "down." They cannot accept that gravity is center-directed if they do not know Earth is spherical. Nor can they believe in a spherical Earth without some knowledge of gravity to account for why people on the bottom do not fall off. Research suggests teaching the concepts of spherical Earth, space, and gravity in close connection to each other. Some research indicates that students can understand basic concepts of the shape of Earth and gravity by grade 5 if students' ideas are directly discussed and corrected in the classroom. (*Benchmarks for Science Literacy*, p. 335)

Explanations of the day/night cycle, phases of the moon, and seasons are very challenging for students. To understand these phenomena, students should first master the idea of a spherical Earth, itself a challenging task. Similarly, students must understand the concept of light reflection and how the moon gets its light from the sun before they can understand the phases of the moon. Finally, students may not be able to understand explanations of any of these phenomena before they reasonably understand the relative size, motion, and distance of and among the sun, moon, and Earth. (*Benchmarks for Science Literacy*, pp. 335 and 336)

Grade 5 Science, Quarter 2, Unit 2.3

Processes That Shape the Earth—Geology

Overview

Number of instructional days: 12 (1 day = 45 minutes)

Content to be learned

- Identify and describe the layers of Earth.
- Demonstrate an understanding of change by representing the processes of the rock cycle in words, diagrams, or models.

Science processes to be integrated

- Use or build models to demonstrate an understanding of interactions and change that occur within systems.
- Represent a system using words, diagrams, and models.

Essential questions

- What characteristics distinguish one layer of Earth from another?
- How do heat, pressure, and time cause change to rocks?

Written Curriculum

Grade-Span Expectations

ESS1 - The earth and earth materials as we know them today have developed over long periods of time, through continual change processes.

ESS1 (5-8) INQ+ POC –1

Use geological evidence provided to support the idea that the Earth's crust/lithosphere is composed of plates that move.

ESS1 (5-6)–1 Students demonstrate an understanding of processes and change over time within earth systems by …

1a identifying and describing the layers of the earth.

ESS1 (5-8) INQ+ POC –5

Using data about a rock's physical characteristics make and support an inference about the rock's history and connection to rock cycle.

ESS1 (5-6)-5 Students demonstrate an understanding of processes and change over time by …

5a representing the processes of the rock cycle in words, diagrams, or models.

Clarifying the Standards

Prior Learning

In grades K–2, students demonstrated an understanding of earth materials by describing, comparing, and sorting rocks and soils by similar or different physical properties, (e.g. size, shape, color, texture, smell weight). They recorded observations/data about physical properties and used attributes of properties to state why objects are grouped together (e.g., rocks that are shiny or not shiny). Further, students identified which earth materials are best for different uses (e.g., soil for growing plants, sand for sandbox). They also demonstrated an understanding of processes and change over time within earth systems by conducting tests on how different soils retain water (e.g., How fast does the water drain through?).

In grades 3 and 4, students demonstrated an understanding of earth materials by describing, comparing, and sorting rocks, soils, and minerals by similar or different physical properties (e.g., size, shape, color, texture, smell, weight, temperature, hardness, composition). They recorded and analyzed observations/ data about physical properties (e.g., within a grouping, which characteristics are the same and which are different) and cited evidence (e.g., prior knowledge and data) to support why rocks, soil, or minerals are classified/not classified together. Students identified the four basic materials of Earth (water, soil, rocks, air) and determined and supported explanations of their uses (e.g., best soils to grow plants, best building material for a specific purpose, determining which rock size best prevents erosion).

In addition, students in grades 3 and 4 demonstrated an understanding of processes and change over time within earth systems by conducting investigations and using observational data to describe how water

moves rocks and soils. They investigated local landforms and how wind, water, and ice have shaped or reshaped them. Students used or built models to simulate the effects of how wind and water shape and reshape the land (e.g., erosion, sedimentation, deposition, glaciation), and they identified sudden and gradual changes that affect Earth.

Current Learning

Changes to the surface of Earth happen over long periods of time, and this makes it difficult for elementary students to comprehend that the processes that cause these changes are occurring all the time. Although students have explored different types of rocks and observed how water moves across and shapes the land, identifying and describing the layers of Earth and representing the processes of the rock cycle in words, diagrams, and models are new concepts for grade 5. These concepts should be taught at the developmental level to reinforcement level of instruction.

The layers of Earth are not separate entities, but are integral components in the processes that continually shape Earth. Although it may be tempting to teach fifth graders about plate tectonics, students should focus solely on identifying and describing the layers of Earth. Because Earth's layers (crust, mantle, and core) cannot be directly observed, a variety of models should be used, including everyday items such as hard-boiled eggs or peaches, to illustrate the layers of Earth. Teachers can also use books, magazines, websites, and other online resources to help illustrate this concept for students.

Regarding the rock cycle, students learn that rocks at the surface of Earth are weathered in various ways, which form sediments that are eroded away, buried, compacted, heated, and often recrystallized into new rock that may be brought back to the surface by other forces/processes within Earth, and the cycle repeats. The multiple processes involved in the rock cycle are complex, and instruction should be planned carefully. Because all the processes that make up the rock cycle take a great amount of time, the cycle cannot be directly observed. In most cases, you can only observe the effects of these processes. Therefore, teachers should select a variety of investigations in which students can use models and simulations to observe one or more of the processes that comprise this cycle. For example, a stream table may be used to model the processes of erosion and deposition. To model weathering, students could conduct an investigation in which they put a piece of chalk (representing a "softer" type of rock like sandstone or limestone) inside a bag with some small- to medium-sized rocks. As the students shake the bag, the rocks break down, or weather the chalk, turning it into "sediment." Other processes that cause weathering, including ice wedging and biological weathering by plants, can be modeled by freezing a water balloon or planting water-soaked seeds inside a block of plaster of Paris. To simulate sedimentation, students can place a number of different sediments (clay, sand, silt, gravel, bits of dead leaves and grasses) into a plastic bottle, fill it with water, and then shake the bottle. The sediments settle in layers, giving students a visual model of the sedimentation process that occurs in rivers and lakes. To help students understand what happens to sediments after they are buried, the class could observe a model in which crayon shavings of different colors represent sedimentary rock. These sediments are pressed or hammered together inside a piece of foil. This represents compacting. This compacted package could then be heated, resulting in a "new" rock formation.

While models help you visualize processes that are too slow or too fast to directly observe or are at a scale that is too large or too small to see, every model/simulation has strengths and limitations. Whenever a model or simulation is used in the classroom, students must have time to compare and analyze the model to the processes in the natural world and discuss the model's strengths and limitations. Additionally, although there are a number of videos and online resources available to help students understand the processes of the rock cycle, some may contain content that is beyond the understanding of fifth graders.

Also, even though teachers introduce the three types of rock during this unit of study, students should not be assessed on their ability to classify or identify a given rock as sedimentary, metamorphic, or igneous. The focus in this unit is on using pictures, diagrams, words, and models to represent the processes that cause change to rocks and soils.

Future Learning

In grade 6, students will continue to demonstrate an understanding of processes and change over time within earth systems by plotting the location of volcanoes and earthquakes and explaining the relationship between the location of these phenomena and faults. They will represent the processes of the rock cycle in words, diagrams, and models, and they will cite evidence and develop a logical argument to explain the formation of a rock, given its characteristics and location.

In grades 7 and 8, students will demonstrate an understanding of processes and change over time within earth systems by citing evidence and developing a logical argument for plate movement using fossil evidence, layers of sedimentary rock, the location of mineral deposits, and the shape of the continents. They will evaluate slow processes (e.g., weathering, erosion, mountain building, seafloor spreading) and fast processes (e.g., erosion, volcanoes, earthquakes) to determine how Earth has changed and will continue to change over time. Additionally, students will investigate the effect of flowing water on landforms.

Additional Findings

A major goal of science in the middle grades is for students to develop an understanding of the four major interacting components of the earth system—geosphere (crust, mantle, core), hydrosphere (water), atmosphere (air), and biosphere (the realm of all living things). There are physical, chemical, and biological processes that act within and among the four components on a wide range of time scales to continuously change Earth's crust, oceans, atmosphere, and organisms. For this unit of study, it is fundamental for students to understand that some changes in the solid Earth can be described as the rock cycle. Old rocks at the Earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues. (*National Science Education Standards*, pp. 158–160)

Students of all ages may hold the view that the world was always as it is now or that changes that have occurred must have been sudden and comprehensive. (*Atlas of Science Literacy, Vol. 1*, p. 50) Students should understand that change happens to many things, some changes are so slow or so fast that they are difficult to see, and things change in steady, repetitive or irregular ways—or sometimes in more than one way at the same time. Rock is composed of different combinations of minerals. Smaller rocks come from the breakage and weathering of bedrock and larger rocks. Soil is made partly from weathered rock and partly from plant remains, and it also contains many living organisms. Sediments of sand and smaller particles are gradually buried and cemented together by dissolved minerals to form solid rock again. Sedimentary rock buried deep enough may be reformed by pressure and heat, perhaps melting and recrystallizing into different kinds of rock. These reformed rock layers may be forced up again to become land surface. Subsequently, this new rock too will erode. (p. 51)

According to *Benchmarks for Science Literacy,* students in grades 3–5 should become adept at using magnifiers to inspect a variety of rocks and soils; however, the point is not to classify rigorously but to notice the variety of components. They should also observe elementary processes of the rock cycle—weathering, erosion, and deposition. Water, sandboxes, and rock tumblers can provide them with some

firsthand examples. Later, they can connect the features to the processes and follow explanations of how the features came to be and still are changing. (p. 72)

According to the research found in *Making Sense of Secondary Science*, very few children appreciate the relationship between sedimentary rocks and the sedimentary processes by which they are formed. Additional confusion arises when children mix up the layers apparent in sedimentary rocks with the cleavage planes often associated with metamorphic rocks. Small minorities of children associate igneous rocks with fire or volcanoes. Children sometimes associate the word *metamorphic* with *metamorphosis* in animals, and they linked metamorphic rocks with butterflies and plants in general. (p. 113)