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MODEL CURRICULUM GRADE 6

EARTH AND SPACE SCIENCE (ESS)

Topic: Rocks, Minerals and Soil

This topic focuses on the study of rocks, minerals and soil, which make up the lithosphere. Classifying and identifying different types of rocks, minerals and soil can decode the past environment in which they formed.

CONTENT STATEMENT

Minerals have specific, quantifiable properties.

Minerals are naturally occurring, inorganic solids that have a defined chemical composition. Minerals have properties that can be observed and measured. Minerals form in specific environments.

CONTENT ELABORATION

Prior Concepts Related to Mineral Properties

PreK-2: Objects have physical properties, properties of objects can change, and Earth's nonliving resources have specific properties.

Grades 3-5: Rocks and soil have characteristics, soil contains pieces of rocks, and objects are composed of matter and may exhibit electrical conductivity and magnetism.

Grade 6 Concepts

Most rocks are composed of one or more minerals. Minerals have specific properties that can be used for identification. The properties that can be used for testing minerals include luster, hardness, cleavage, streak, magnetism, fluorescence and/or crystal shape. The emphasis is on learning how to identify the mineral by conducting tests (not through memorization). Common minerals (including those on Mohs' hardness scale) must be used in the identification process. A representative sample of minerals can be used so that different testing methods can be applied and demonstrated. Appropriate tools and safety procedures must be used to test mineral properties. Technology can provide identification information and research materials to assist in mineral investigations.

Minerals present in rocks can help identify the rocks correctly. Minerals can indicate the type of environment in which the rock and/or mineral formed. Some minerals (e.g., halite, varieties of gypsum) form through evaporation and some (e.g., calcite) form through a variety of chemical processes. Other minerals (e.g., feldspar varieties, magnetite, varieties of quartz) form in an igneous environment and some minerals (e.g., epidote) form in a metamorphic environment.

Future Application of Concepts

Grades 7-8: Biogeochemical cycles, igneous environments and the history of Earth (including the changing environments) from the interpretation of the rock record are studied.

High School: The formation of elements, chemical bonding and crystal structure are found in the Physical Sciences. In grades 11-12 Physical Geology, mineralogy is explored at depth.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning, and to develop summative assessment of student learning of science.

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS	DEMONSTRATING SCIENCE KNOWLEDGE	INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS	RECALLING ACCURATE SCIENCE
Determine, using scientific investigation, the best mineral to use to solve a problem or serve a specific function. Ask: *What is the best mineral or rock to use to neutralize acidic soil? What is the best rock to use to make a statue? What is the best mineral to use for sandpaper?* Evaluate the results and use the data to draw a conclusion. Share findings with an authentic audience.	Simulate the formation of halite or gypsum in the Lake Erie area through a scientific experiment. Using data from the evaporate simulation; predict how long it took to form the existing formations.	Research and document the **environmental conditions** (select Silurian Period) that existed when halite and gypsum formed in the Lake Erie area of Ohio.	Identify the common rock-forming minerals (e.g., calcite, halite, dolomite, gypsum, quartzes, feldspars, micas, talc, kaolinite, chalk, topaz, corundum).
		Make a dichotomous key, using mineral properties, to use in testing and identifying minerals.	Identify the different processes and/or environments in which minerals can form (e.g., evaporation, chemical processes, sedimentary, igneous or metamorphic).
		Compare and contrast rocks and minerals.	Recognize that minerals have measurable properties that can be used for identification and/or classification.

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INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- Allowing student investigation in the testing of different mineral properties is a key part of really understanding minerals. The properties of the mineral define its value and uses. The **USGS** provides mineral resources and information that can support the teaching of minerals. Specific mineral data is available using the website's search engine.
- Understanding how to test minerals accurately is essential in identifying minerals correctly. Identification should not be based upon visuals, but rather testing and analyzing the results. Many minerals can look or feel the same, so it is important to encourage students to run tests before identifying an unknown mineral. The **Mineralogical Society of America** offers training, workshops, data and resources to support learning about minerals and geology.
- Connecting mineral uses with mineral identification is an important part of teaching about minerals with connections to the real world. **Geology.com** provides information on each major mineral type or group with details on mineral properties and uses.

Career Connection

Explore the uses of mineral properties across various careers (e.g., construction and sand paper; acidic soil and landscaping or agriculture). Lead a discussion where you will assist students with identifying the careers and roles involved in such a process, such as:

- Geologist: people who study rocks, minerals, and composition
- Machine Operator: the person who operates equipment
- Site Manager: oversees each role and responsibility on the job site
- Environmentalists: concerned with the environmental impact of projects
- Engineer: understand and design the process, which includes the types of materials used

Host a career speaker who represents one of the roles involved in the process. The speaker can share their responsibilities and how they interact with others to complete a project.

COMMON MISCONCEPTIONS

- Carleton College provides geology-specific assessment techniques that can identify misconceptions, lists of common Earth science misconceptions and resources to correct misconceptions at **http://serc.carleton.edu/NAGTWorkshops/teaching_methods/conceptests/index.html**.
- NASA provides a list of overarching Earth Science questions that address many of the common misconceptions at this grade level. There are resources and information that help address questions that center on Earth Systems Science at **http://science.nasa.gov/big-questions/**.

DIVERSE LEARNERS

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MODEL CURRICULUM GRADE 6

EARTH AND SPACE SCIENCE (ESS)

Topic: Rocks, Minerals and Soil

This topic focuses on the study of rocks, minerals and soil, which make up the lithosphere. Classifying and identifying different types of rocks, minerals and soil can decode the past environment in which they formed.

CONTENT STATEMENT

Igneous, metamorphic and sedimentary rocks have unique characteristics that can be used for identification and/or classification.

Most rocks are composed of one or more minerals, but there are a few types of sedimentary rocks that contain organic material, such as coal. The composition of the rock, types of mineral present, mineral arrangement, and/or mineral shape and size can be used to identify the rock and to interpret its history of formation, breakdown (weathering) and transport (erosion).

CONTENT ELABORATION

Prior Concepts Related to Rocks

PreK-2: Objects have physical properties, properties of objects can change and Earth's nonliving resources have specific properties.

Grades 3-5: Rocks and soil have characteristics, soil contains pieces of rocks, rocks form in different ways, and objects are composed of matter and may exhibit electrical conductivity and magnetism.

Grade 6 Concepts

Rock identification and classification must be experiential and investigative. Common samples to use in identification should be representative of each type of rock. Igneous samples must include varieties of granite, rhyolite, basalt, obsidian, pumice and andesite. Metamorphic samples must include varieties of schist, gneiss, slate, marble, anthracite and phyllite. Sedimentary samples must include varieties of limestone, sandstone, shale, conglomerate and breccia. Other rock samples such as bituminous coal, coquina and chert must be included in identification investigations, but these may not always fall neatly into one specific rock category. Proper safety protocol and testing procedures must be used.

It is important to use the identification of the minerals, mineral arrangement (within the rock) and quantifiable characteristics of the rock to identify the rock. Analysis of specific rock characteristics can be conducted in the classroom or in nature with rock samples. Technology can be used to research current identification methods and techniques and assist in methods of determining the quantifiable characteristics of specific rocks.

The purpose of rock identification must be related to understanding the environment in which the rock formed.

Future Application of Concepts

Grades 7-8: Sedimentary, metamorphic and igneous environments, and the history of Earth (including the changing environments) from the interpretation of the rock record are studied.

High School: The formation of elements, chemical bonding and crystal structure are found in the Physical Sciences. In grades 11/12 Physical Geology, depositional environments, volcanics, characteristics of rocks and mineralogy are explored in depth.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS	DEMONSTRATING SCIENCE KNOWLEDGE	INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS	RECALLING ACCURATE SCIENCE
Determine, using a scientific experiment, the best mineral or rock to use to solve a problem or serve a specific function. Ask: *What is the best mineral or rock to use to neutralize acidic soil? What is the best rock to use to make a statue? What is the best mineral to use for sandpaper?* Evaluate the results and use the data to draw a conclusion. Share findings with an authentic audience. **Note: This project can be used for understanding both mineral and rock properties and their uses, because minerals are found within rocks.**	The unique characteristics of rocks can be used to determine how the rock formed or how the rock can be used. Plan and implement an investigation that analyzes the characteristics of rocks used locally (e.g., in landscape projects, buildings, floors, statues, gravestones, patios/walls). Ask: *What characteristics allow the rock to work well/not work well in that environment?*	Make a chart, table or key to use in the classification of common rocks within each division of rock (sedimentary, igneous, metamorphic).	Recognize that each type of rock has a unique history based upon the environmental conditions that existed when it formed.

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INSTRUCTIONAL STRATEGIES AND RESOURCES

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- Involving students in rock collecting and building a classroom set of representative rocks can be a way to connect the classroom to what students see locally. The **USGS** provides a list of resources and links to help in the teaching of rock identification and rock formation at the middle school level. It is important that students identify and classify rocks using specific characteristics, such as what minerals are present and texture/grain size. Appearance alone should not be relied upon for identification.
- It is important to teach how specific types of rocks form and connect this teaching to understanding Earth's history. The **National Earth Science Teachers Association** provides background information about the formation of each type of rock (sedimentary, metamorphic and igneous). In addition, information is provided about minerals found in the rocks.
- Introducing students to topographic and geologic maps can be used to connect the local geology to what is being taught in the classroom. ODNR's **Division of Geological Survey** provides a number of resources that link to Ohio specific geology, including a variety of geologic maps and information about the history of Ohio's geologic history.
- **NSTA** provides learning modules called SciPacks that are designed to increase teacher content knowledge through inquiry-based modules. This module addresses rock-forming environments.
- The **College Board** provides Earth Science recommendations for grades 6-12 (beginning on page 21). Essential questions and scientific applications are included in this document to encourage investigation and scientific inquiry. In addition, connections to other topics and subjects are suggested to add relevancy and interest for students.

COMMON MISCONCEPTIONS

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MODEL CURRICULUM GRADE 6

EARTH AND SPACE SCIENCE (ESS)

Topic: Rocks, Minerals and Soil

This topic focuses on the study of rocks, minerals and soil, which make up the lithosphere. Classifying and identifying different types of rocks, minerals and soil can decode the past environment in which they formed.

CONTENT STATEMENT

Igneous, metamorphic and sedimentary rocks form in different ways.

Magma or lava cools and crystallizes to form igneous rocks. Heat and pressure applied to existing rock forms metamorphic rocks. Sedimentary rock forms as existing rock weathers chemically and/or physically and the weathered material is compressed and then lithifies. Each rock type can provide information about the environment in which it was formed.

CONTENT ELABORATION

Prior Concepts Related to Rocks

PreK-2: Objects have physical properties, properties of objects can change and Earth's nonliving resources have specific properties.

Grades 3-5: Rocks and soil have characteristics, soil contains pieces of rocks, rocks form in different ways, and objects are composed of matter and may exhibit electrical conductivity and magnetism.

Grade 6 Concepts

Rocks and minerals in rocks form in specific types of environments. The rock cycle can be used for a general explanation of the conditions required for igneous, metamorphic and sedimentary rocks to form, but additional information should be added for relevancy. For example, the typical pattern of coal formation is an important connection to energy in Ohio and should be included. Another example would be the formation of Ohio sandstone and limestone indicating that a shallow sea once covered Ohio. Ohio's geologic history and past environmental conditions play an important role in understanding the existing bedrock in Ohio.

Conducting field investigations, taking field trips, geologic maps, virtual field trips, physical maps and topographic maps can be used to illustrate how types of geologic structures and features help identify the types of rock that may be found in specific areas. This must be connected to an understanding about the environmental conditions that needed to exist during the formation.

Future Application of Concepts

Grades 7-8: Sedimentary, metamorphic and igneous environments, and the history of Earth (including the changing environments) from the interpretation of the rock record are studied.

High School: The formation of elements, chemical bonding and crystal structure are found in the Physical Sciences. In grades 11/12 Physical Geology, depositional environments, volcanics, characteristics of rocks and mineralogy are explored in depth.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning, and to develop summative assessment of student learning of science.

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS	DEMONSTRATING SCIENCE KNOWLEDGE	INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS	RECALLING ACCURATE SCIENCE
Make a geologic map of the local community. Use existing geologic data, historic (geologic) data and field exploration to analyze types of formations that are present. Use the finished map to evaluate possible land and resource uses. Present the map and recommendations to an authentic audience.	Using a geologic map of a region of the United States, determine what types of rocks are represented (igneous, sedimentary, metamorphic). Based on the environment required for these rock types to form, develop a hypothesis regarding the geologic history of the region. Research the actual geologic history of the region and compare to findings. Discuss reasons for the similarities and differences with the class.	Use the rock cycle to describe the formation of igneous, sedimentary and metamorphic rocks.	Identify the main components of the rock cycle.

INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- ODNR's **Division of Geological Survey** provides interactive maps and geologic maps that can be used to show local and statewide surficial and bedrock geology. There are many other resources that help support the teaching of rocks and the rock cycle. Information from this website also can be used to help prepare students to make their own geologic maps of their local communities.
- The **USGS** provides a list of resources and links to help in the teaching of rock identification and rock formation at the middle school level.
- **NSTA** offers a number of helpful books and resources that address the rock cycle and learning about the environment in which rocks form. This is a link to Rocks SciPack, which can be a good starting point for most teachers.

COMMON MISCONCEPTIONS

- Carleton College provides geology-specific assessment techniques that can identify misconceptions, lists of common Earth science misconceptions and resources to correct misconceptions at **http://serc.carleton.edu/NAGTWorkshops/teaching_methods/conceptests/index.html**.
- NASA provides a list of overarching Earth Science questions that address many of the common misconceptions at this grade level. There are resources and information that help address questions that center on Earth Systems Science at **http://science.nasa.gov/big-questions/**.

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DIVERSE LEARNERS

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MODEL CURRICULUM GRADE 6

EARTH AND SPACE SCIENCE (ESS)

Topic: Rocks, Minerals and Soil

This topic focuses on the study of rocks, minerals and soil, which make up the lithosphere. Classifying and identifying different types of rocks, minerals and soil can decode the past environment in which they formed.

CONTENT STATEMENT

Soil is unconsolidated material that contains nutrient matter and weathered rock.

Soil formation occurs at different rates and is based on environmental conditions, types of existing bedrock and rates of weathering. Soil forms in layers known as horizons. Soil horizons can be distinguished from one another based on properties that can be measured.

Note: The introduction to soil is found in grade 3.

CONTENT ELABORATION

Prior Concepts Related to Soil

PreK-2: Objects have physical properties, properties of objects can change and Earth's nonliving resources have specific properties.

Grades 3-5: Rocks and soil have characteristics. Soil contains pieces of rocks. Soil investigations measure color, texture, ability for water to pass through soil, moisture content and soil composition. Objects are composed of matter.

Grade 6 Concepts

Soil sampling and testing must be used to investigate soil. Soil forms at different rates and has different measurable properties, depending on the environmental conditions. Properties in soil that are useful in soil identification include texture, color, composition, permeability and porosity. Uses of soil depend upon their properties. For example, some soils may be recommended for agriculture, while others may be used for brick making or creating a pond.

Observing and identifying soil horizons are based upon understanding the different properties of soil and when the properties change. Soil sampling testing methods and equipment are included within this content statement. Soil maps (paper or digital) combined with geologic, aerial or topographic maps can assist in local identification of soil formations. A connection must be made to environmental conditions, types of bedrock and soil properties.

Appropriate tools and safety procedures must be used in all soil investigations.

Note: It is important to use the term "soil," not "dirt." Dirt and soil are not synonymous.

Future Application of Concepts

Grades 7-8: Biogeochemical cycles and the role of soil within them, soil erosion and runoff issues, hydrologic cycle including percolation and infiltration rates, and sedimentary environments are studied.

High School: The formation of elements, the importance of soil in an ecosystem, and issues with soil degradation and soil loss are explored. In grades 11/12 Physical Geology, depositional environments, soil mechanics, issues with mass wasting including soil/sediment contamination issues and the classification of soil is found.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning, and to develop summative assessment of student learning of science.

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS	DEMONSTRATING SCIENCE KNOWLEDGE	INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS	RECALLING ACCURATE SCIENCE
During some flooding events, sandbags are used to slow down or redirect floodwaters. Develop a list of criteria required for the bags. Using four or five unknown soil samples, design and conduct an investigation to determine which soil is best to use inside the sandbags. Analyze the soil data and test results to make the final determination. Share findings and the decision with the class.	Plan and implement an investigation to compare a specific and identifiable soil horizon in different locations within the community. Compare and contrast the depth and width of the **soil horizons**. Research and explain the differences that are measured.	Differentiate between the different **soil horizons** (O, A, B and C) using the standard composition of each.	Recognize that soil layers are called horizons and each horizon has properties that can be measured. Identify the types of conditions that may contribute to the formation of soil or lack of formation of soil.
	Plan and implement an investigation to determine which types of soil (sand, clay, loam, silt, gravel) are most likely to fail in a landslide event. Use the total volume of water added to calculate the percent saturation for each sample. Analyze the data and write a conclusion.	Research areas of past or present soil depletion (e.g., the dust bowl, desertification, mass wasting, erosion). Present findings to the class orally or in writing.	Use specific tools to measure soil characteristics and properties (e.g., permeability, porosity, texture, color).

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INSTRUCTIONAL STRATEGIES AND RESOURCES

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- Investigating local and statewide soil types and comparing them to actual tests of local soil samples can be a good starting point in understanding soil. Lists of **soil types by state** can be used to begin this process.
- Examining student-based (classroom data) soil-sample results can be a good way to compare soil types by regions. **The GLOBE program** allows connections to other classrooms and can be used to analyze data beyond the local area to draw conclusions about specific criteria for soil formation.
- Specific resources related to **Ohio soil**, including Web-based survey tools, interactive **maps** and mapping programs, can be used in the identification of local and state soil.
- **NSTA** offers reference books and materials that help students understand the properties and uses of soil at the middle school level.
- The **USGS** has a resource page that provides data, information, books and maps that relate to Earth's surface, soils, soil formation, weathering and erosion.
- Allowing students to test the properties of soil leads to a deeper understanding of soil formation, local soils and the importance of soil. Soil types, **testing and use**, and understanding the methods required for analysis of soils can further demonstrate the importance of soil conservation.
- Local **Soil and Water Conservation Districts** can offer multiple environmental educational resources that pertain directly to soil uses, conservation of soil, soil testing and interpretation of soil data.
- Introducing problem-solving skills through the application of science can deepen the content knowledge for soils. Testing soils to determine which types of soil would work best in a specific situation is a good way to connect soils and soil uses to the real world. One example (provided in the Vision into Practice section) involves determining which soil is best to use to deter floodwaters. The **sandbag** example provides inquiry and engineering design for students of all ability levels.

COMMON MISCONCEPTIONS

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MODEL CURRICULUM GRADE 6

EARTH AND SPACE SCIENCE (ESS)

Topic: Rocks, Minerals and Soil

This topic focuses on the study of rocks, minerals and soil, which make up the lithosphere. Classifying and identifying different types of rocks, minerals and soil can decode the past environment in which they formed.

CONTENT STATEMENT

Rocks, minerals and soils have common and practical uses.

Nearly all manufactured material requires some kind of geologic resource. Most geologic resources are considered nonrenewable. Rocks, minerals and soil are examples of geologic resources that are nonrenewable.

Note: Nonrenewable energy sources should be included (such as fossil fuels).

CONTENT ELABORATION

Prior Concepts Related to Uses of Rocks, Minerals and Soil

PreK-2: Objects have physical properties, properties of objects can change and Earth's nonliving resources have specific properties.

Grades 3-5: Rocks and soil have characteristics, Earth's resources can be used for energy, renewable and nonrenewable resources, some of Earth's resources are limited.

Grade 6 Concepts

Rocks, minerals and soils have specific physical properties that determine how they can be used. The different methods of extracting the resources should be included. Uses of the resources should include construction (e.g., gypsum, metals, gravel, sand, lime, clay), energy (e.g., fossil fuels, radioactive materials), transportation (e.g., road salt, asphalt), agriculture (e.g., lime, peat, minerals for fertilizers, pesticides), domestic use (e.g., metals and gems for jewelry, clay for pottery or sculpting, natural dyes for clothing or paint) and technology (e.g., lithium, silica).

The conservation of resources through the management of the resources, which includes extraction methods, use, storage and disposal, is an important part of understanding the uses of rocks, minerals and soil.

Future Application of Concepts

Grades 7-8: Biogeochemical cycles (including the hydrologic cycle) are related to erosion and weathering of rock, minerals and soil. The history of Earth (including the formation of nonrenewable resources) from the interpretation of the rock record are studied.

High School: The formation of elements, chemical bonding and nuclear energy are found in the Physical Sciences. In grades 11/12 Physical Geology, Earth's resources and specific laws pertaining to the resources are explored at a greater depth.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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During some flooding events, sandbags are used to slow down or redirect floodwaters. Develop a list of criteria required for the bags. Using four or five unknown soil samples, design and conduct an investigation to determine which soil is best to use inside the sandbags. Analyze the soil data and test results to make the final determination. Share findings and the decision with the class.	Plan and implement an investigation to compare a specific and identifiable soil horizon in different locations within the community. Compare and contrast the depth and width of the **soil horizons**. Research and explain the differences that are measured.	Research different uses of minerals, soil and rock within the community and within Ohio. Represent findings graphically and discuss/present to the class.	Recognize that the characteristics of soil, rocks and minerals determine how they can be used.
	Design an investigation that can test slope stability and landslides, by creating mountains out of different materials (e.g., sand, gravel, clay). Water is added to test the stability of each material. Analyze data and write a conclusion to represent the findings.	Make a map or 3-D model of Ohio that illustrates the major geologic resources that are found. Share the final product with the class.	Identify examples of different ways that soil, rocks and minerals can be used.

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INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- It is important to relate the properties of minerals and the characteristics of rocks and soil to their value and use as resources. The **USGS** provides mineral resources and information that can support the teaching of minerals at the middle school level. Specific mineral data is available using the search engine on this USGS mineral resource Web page.
- ODNR's **Mineral Resource Division** provides Ohio-specific mineral resources, mineral uses and data regarding these resources. Students should be encouraged to investigate the different uses for geologic resources in Ohio. Ask: *What properties allow this rock, mineral or soil to be used for this purpose?* There must be a connection between the physical and chemical properties and the use.
- Connecting mineral, soil or rock resource use with the historical information about geologic resource use in Ohio can engage students and deepen the knowledge of resources in Ohio. **A brief history of Ohio's geologic resources** allows students to research changes that have occurred in resource use. Mining techniques can be a good connection to the real world and the environment.
- **NSTA** provides learning modules called SciPacks that are designed to increase teacher content knowledge through inquiry-based modules. This module addresses the Earth's Resources, including the uses of resources.
- Having **reference** and **resource** materials in the classroom can help in the interpretation and analysis of soil data.
- Introducing problem-solving skills through the application of science can deepen the content knowledge for soils. Testing soils to determine which types of soil would work best in a specific situation is a good way to connect soils and soil uses to the real world. One example (provided in the Vision into Practice section) involves determining which soil (from four or five unknown samples) is best to use to deter floodwaters. The **sandbag** example provides inquiry and engineering design for students of all ability levels.

COMMON MISCONCEPTIONS

- NASA lists common misconceptions for all ages about the sun and the Earth at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- Carleton College provides geology-specific assessment techniques that can identify misconceptions, lists of common Earth science misconceptions and resources to correct misconceptions at **http://serc.carleton.edu/NAGTWorkshops/teaching_methods/conceptests/index.html**.
- NASA provides a list of overarching Earth Science questions that address many of the common misconceptions at this grade level. There are resources and information that help address questions that center on Earth Systems Science at **http://science.nasa.gov/big-questions/**.

DIVERSE LEARNERS

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MODEL CURRICULUM GRADE 6

LIFE SCIENCE (LS)

Topic: Cellular to Multicellular

This topic focuses on the study of the basics of Modern Cell Theory. All organisms are composed of cells, which are the fundamental unit of life. Cells carry on the many processes that sustain life. All cells come from pre-existing cells.

CONTENT STATEMENT

Cells are the fundamental unit of life.

All living things are composed of cells. Different body tissues and organs are made of different kinds of cells. The ways cells function are similar in all living organisms.

Note 1: Specific information about the organelles that need to be addressed at this grade level will be found in the model curriculum.

Note 2: Emphasis should be placed on the function and coordination of these components, as well as on their roles in overall cell function.

CONTENT ELABORATION

Prior Concepts Related to Species and Reproduction

PreK-2: Living things have specific traits and are made up of a variety of structures.

Grades 3-5: Organisms are made of parts.

Grade 6 Concepts:

The content statements for sixth-grade Life Science are each partial components of a large concept. The parts have been isolated to call attention to the depth of knowledge required to build to one of biology's foundational theories, Modern Cell Theory. It is recommended that the content statements be combined and taught as a whole. For example, the energy needs of cells can be interwoven with the function of mitochondria.

Modern Cell Theory states that all living things are made of cells. Cells are the basic unit of structure and function of all living things. Many organisms are single-celled and that one cell must carry out all the basic functions of life. Other organisms are multicellular and the cells that form these organisms can be organized at various levels to carry out all the basic functions of life. Different body tissues and organs can be made up of different kinds of cells. The cells in similar tissues and organs in animals are similar. The tissues and organs found in plants differ slightly from similar tissues in animals. Use Modern Cell Theory to exemplify how scientific theories are developed over time.

Microscopes, micrographs, safety procedures, models and illustrations must be used to observe cells from many different types of organisms. Representative cells from eubacteria (cynaobacteria), protista (algae, amoeba, diatoms, euglena, volvox) and fungi (common mushrooms, bread molds) must be observed for cell structures such as the cell wall, cell membrane and nucleus. Plantae cells (mosses, ferns and angiosperms) must be observed for the following cell components: nucleus, mitochondria, chloroplast, ribosome, plasma membrane, vacuole and lysosome. Mitochondria and ribosomes are not visible under regular light microscopes but may be viewed using micrographs or illustrations. The differences in sizes and shape of various cells and organelles must be noted. Size is a useful tool in identification of cells. The relationship between structure and function is a crosscutting theme for science and should be explored when investigating the structure and function of cellular organelles. Emphasis must be placed on the function and coordination of these components, as well as on the overall cell function, before introducing and reinforcing the names of these components (e.g., plant and algae cells contain plastids where the manufacture and storage of chemical compounds important to the cell occur). The most commonly described plastids are chloroplasts in green plant cells.

Microscopes must be used to view a variety of cells (see above), tissues (xylem, phloem, connective, muscle, nervous) and organs (leaf, stem, flower, spore, ganglia, blood vessels, eyes) to compare and contrast their similarities and differences. Real-world applications, new technology and contemporary science must be used in this content (e.g., the presence of microbes in potable water can be a way to connect the solutions to real-world problems and biology).

Future Application of Concepts

High School: Details of cellular processes such as photosynthesis, chemosynthesis, cellular respiration, cell division and differentiation are studied. Cellular organelles studied are cytoskeleton, Golgi complex and endoplasmic reticulum.

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EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning, and to develop summative assessment of student learning of science.

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Analyze and evaluate scientific tradeoffs (e.g., environmental, projected research required to move from current knowledge to application) for use of microbes to produce alternative energy or clean up environmental spills.	Predict what will happen when a cell is placed in solutions of varying concentration levels. Then plan and conduct a scientific investigation to prove or disprove predictions.	Build a model of a plant or animal cell and explain how the cellular structures and their functions contribute to the survival of the cell.	Describe how the structure of specialized cells that form tissues (e.g., xylem, phloem, connective, muscle, nervous) relates to the function that the cells perform.
		Using microscopes, micrographs, models or illustrations, observe a single-celled organism. Label the visible cellular structures and explain how a single-celled organism carries out all functions required for life.	

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INSTRUCTIONAL STRATEGIES AND RESOURCES

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- The **University of Utah's Genetic Learning Center** has an interactive (move the scroll bar from left to right) site to explore cell size and scale. This helps make the connection between cell size and how many cells are required to make tissues, organs and organ systems of entire organisms.
- Prepare slides with a variety of **cell samples** for viewing under the microscope to examine a variety of cells. The cells should be from different parts of the organism and from different organisms. Make comparisons between the cells based on their location and origin. Explain why they have the structure and function that they do. **Oklahoma City Community College's website** has detailed information on how to use a microscope. Click on the *Biology* button, then click *Introduction to the Microscope*. Using information from observations and cell research, build a model of a cell. This **organizational tool** can be used to document findings.
- **Cells Alive** and the **University of Utah** offer an interactive animated view of the interior of a cell. The organelles and their functions are the focus.
- **Vision Learning** provides teacher background information about the cell and its discovery.

COMMON MISCONCEPTIONS

- **San Diego State University** provides a list of naïve ideas that children hold about cells along with the scientific idea that needs to be established to correct misconceptions.

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MODEL CURRICULUM GRADE 6

LIFE SCIENCE (LS)

Topic: Cellular to Multicellular

This topic focuses on the study of the basics of Modern Cell Theory. All organisms are composed of cells, which are the fundamental unit of life. Cells carry on the many processes that sustain life. All cells come from pre-existing cells.

CONTENT STATEMENT

All cells come from pre-existing cells.

Cells repeatedly divide resulting in more cells and growth and repair in multicellular organisms.

Note: This is not a detailed discussion of the phases of mitosis or meiosis. The focus should be on reproduction as a means of transmitting genetic information from one generation to the next, cellular growth and repair.

CONTENT ELABORATION

Prior Concepts Related to Species and Reproduction

PreK-2: Living things are made up of a variety of structures.

Grades 3-5: Individual organisms inherit many traits from their parents indicating a reliable way to transfer information from one generation to the next.

Grade 6 Concepts

The content statements for sixth-grade life science are each partial components of a larger concept. The parts have been isolated to call attention to the depth of knowledge required to build to one of biology's important foundational theories: Modern Cell Theory. It is recommended that the content statements be combined and taught as a whole.

Modern Cell Theory states that cells come from pre-existing cells. Individual organisms do not live forever therefore reproduction is necessary for the continuation of every species. Traits are passed onto the next generation through reproduction. In single-celled organisms, the process of binary fission produces a new organism. In multicellular organisms, cells multiply for growth and repair.

In this grade, mitosis is explored. All cells contain genetic materials. The genetic material must be described as chromosomes. The chemicals and chemical processes associated with the genetic material are reserved for high school biology. Chromosomes must be described as structures in cells that contain the genetic material. Microscopes, micrographs, models and illustrations can be used to observe cells from different organisms in the process of dividing. It is not appropriate to learn the names of the stages of mitosis. The focus is on observing cells dividing as evidence that cells come from pre-existing cells and genetic material is transmitted from parent cell to daughter cells.

The misconception of spontaneous generation can be included in discussions on this topic. The experiments of Redi and Pasteur can be used to explain how evidence can lead to new knowledge, better explanations and spur new technology.

Future Application of Concepts

Grade 8: More details about asexual and sexual reproduction will be studied.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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Analyze and evaluate scientific tradeoffs (e.g., environmental, projected research required to move from current knowledge to application) for use of microbes to produce alternative energy or clean up environmental spills.	Do an observational study of the growth of an organism from zygote through embryogenesis in both plants and animals.	Model the movement of chromosomes during plant cell division and explain why this process ensures genetic information is passed from one generation to the next.	Describe the role of mitosis in singlecelled organisms and multicellular organisms.

INSTRUCTIONAL STRATEGIES AND RESOURCES

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- Prepare slides with a variety of **cell samples** for viewing under the microscope to examine a variety of cells. The cells should be from different parts of the organism and from different organisms. Make comparisons between the cells based on their locations and origins. Explain why they have the structure and function that they do. **Oklahoma City Community College's website** has detailed information on how to use a microscope. Click on the *Biology* button, then click *Introduction to the Microscope*. Using information from observations and cell research, build a model of a cell. This **organizational tool** can be used to document findings.
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COMMON MISCONCEPTIONS

- **San Diego State University** provides a list of naïve ideas that children hold about cells along with the scientific idea that needs to be established to correct misconceptions.
- The Annenberg Media series *Essential Science for Teachers:* **Life Science: Session 1: Children's Ideas** provides greater insight to misconceptions children hold about the origin of living things. The students are elementary in this session but the content is relevant for middle school students. Classroom video and lessons are provided to help students avoid these misconceptions.
- The article *Slow Death of Spontaneous Generation* provides a historical overview of the timeline and scientific experiments performed to dispel the misconception of spontaneous generation.

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MODEL CURRICULUM GRADE 6

LIFE SCIENCE (LS)

Topic: Cellular to Multicellular

This topic focuses on the study of the basics of Modern Cell Theory. All organisms are composed of cells, which are the fundamental unit of life. Cells carry on the many processes that sustain life. All cells come from pre-existing cells.

CONTENT STATEMENT

Cells carry on specific functions that sustain life.

Many basic functions of organisms occur in cells. Cells take in nutrients and energy to perform work, like making various molecules required by that cell or an organism.

Every cell is covered by a membrane that controls what can enter and leave the cell.

Within the cell are specialized parts for the transport of materials, energy capture and release, protein building, waste disposal, information feedback and movement.

Note: Emphasis should be placed on the function and coordination of cell components, as well as on their roles in overall cell function.

CONTENT ELABORATION

Prior Concepts Related to Organisms and Reproduction

PreK-2: Living things have specific traits. Living things require energy, water and a particular temperature range.

Grades 3-5: Organisms are made of parts.

Grade 6 Concepts

The content statements for sixth-grade life science are each partial components of a larger concept. The parts have been isolated to call attention to the depth of knowledge required to build to one of biology's important foundational theories: Modern Cell Theory. In classrooms, it is recommended that the content statements be combined and taught as a whole (e.g., the energy requirements of cells can be interwoven with the function of mitochondria). Cells have particular structures that are related to their functions. These functions are regulated and controlled (e.g., a cell membrane controls what can enter and leave the cell).

The organization of living systems includes explanation of the role of cells, tissues, organs and organ systems that carry out life functions for organisms. These roles include maintaining homeostasis, gas exchange, energy transfers and transformation, transportation of molecules, disposal of wastes and synthesis of new molecules. Connections are to be made between cellular organelles and processes.

Explore (3-D or virtually) conditions that optimize and/or minimize cellular function in a cell or an organism. Technology also can be used to run simulations to investigate specific outcomes and develop predictions about changes in functions.

Future Application of Concepts

Grades 7-8: Photosynthesis and respiration are compared.

High School: Details of cellular processes are studied. Molecules enter and leave the cell by the mechanisms of diffusion, osmosis and active transport.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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Test the effectiveness of a cellular leavening agent (yeast) for making bread under different conditions (e.g., vary the amount of sugar, the type of flour, the type of sugar). After multiple trials, determine which recipe makes the least dense bread (as represented by air spaces).	Conduct an investigation to determine the rate of respiration in yeast cells by varying sugar concentrations or other variables to determine the maximum release of carbon dioxide. **Note: Do not conduct a splint test for carbon dioxide.**	Compare sample cells from different tissues (e.g., muscle, skin, root, stem leaf) in plants and animals.	Describe how different organ systems interact to enable complex multicellular organisms to survive.
	Make a statement about what will happen and then test what happens to a cell when placed in a variety of solutions (e.g., an Elodea cell placed in tap water, distilled water and salt water).		

INSTRUCTIONAL STRATEGIES AND RESOURCES

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MODEL CURRICULUM GRADE 6

LIFE SCIENCE (LS)

Topic: Cellular to Multicellular

This topic focuses on the study of the basics of Modern Cell Theory. All organisms are composed of cells, which are the fundamental unit of life. Cells carry on the many processes that sustain life. All cells come from pre-existing cells.

CONTENT STATEMENT

Living systems at all levels of organization demonstrate the complementary nature of structure and function.

The level of organization within organisms includes cells, tissues, organs, organ systems and whole organisms.

Whether the organism is single-celled or multicellular, all of its parts function as a whole to perform the tasks necessary for the survival of the organism.

Organisms have diverse body plans, symmetry and internal structures that contribute to their being able to survive in their environments.

CONTENT ELABORATION

Prior Concepts Related to Organisms and Reproduction

PreK-2: Living things have specific traits. Living things require energy, water and a particular temperature range.

Grades 3-5: Organisms are made of parts.

Grade 6 Concepts

The content statements for sixth-grade life science are each partial components of a larger concept. The parts have been isolated to call attention to the depth of knowledge required to build to one of biology's important foundational theories: Modern Cell Theory. It is recommended that the content statements be combined and taught as a whole (e.g., levels of organization can be interwoven with the concept of cells as the fundamental unit of life).

Cells perform specialized functions in multicellular organisms. Groups of specialized cells form a tissue such as muscle. Different tissues are, in turn, grouped together to form larger functional units, called organs. Each type of cell, tissue and organ has a distinct structure and set of functions that serve the organism as a whole.

Organisms have diverse body plans, symmetry and internal structures. General distinctions among organisms (e.g., body plans, symmetry, internal structures) that support classifying them into a scientifically based system (a distinction of this grade level from Pre-K to 5) are explored. Organisms sorted into groups share similarities in external structures, internal structures and processes.

The commonality of life can be investigated through observing tissues, organs, cell structures (see limits in previous content statements), systems and symmetry (an approximate balanced distribution of duplicate body parts) for plants and animals.

Part of the exploration of the commonality of living systems can include comparison of cells, types of tissues, organs and organ systems between organisms (see other grade 6 content statements for details).

Inquiry and mathematical relationships should be drawn between cell size and the cell's ability to transport necessary materials into its interior. This link is critical for laying the foundation for the cell cycle in the grade 8.

Future Application of Concepts

Grade 8: Cellular reproduction is studied.

High School: The unity and diversity of life and the evolutionary mechanisms that contribute to the organization of living things are studied.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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	Conduct an investigation to determine the rate of photosynthesis in plants to maximize oxygen production.		

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- Use compare and contrast strategies (e.g., Venn diagrams) to help clarify similarities and differences in types of cells.
- Prepare slides with a variety of **cell samples** for viewing under the microscope to examine a variety of cells. The cells should be from different parts of the organism and from different organisms. Make comparisons between the cells based on their locations and origins. Explain why they have the structure and function that they do. **Oklahoma City Community College's website** has detailed information on how to use a microscope. Click on the *Biology* button, then click *Introduction to the Microscope*. Using information from observations and cell research, build a model of a cell. This **organizational tool** can be used to document findings.
- **Wisc-Online** offers an interactive opportunity to examine an animal cell and learn about the functions of its organelles.
- The **University of Utah's Genetic Learning Center** has an interactive (move the scroll bar from left to right) site to explore cell size and scale. This helps make the connection between cell size and how many cells are required to make tissues, organs and organ systems of entire organisms.
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CLASSROOM PORTALS

These are windows into the classroom through webcasts, podcasts or video clips to exemplify and model classroom methods of teaching science using inquiry.

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies *Greg–Grade 6, Paul–Grade 6* and *Jeff–Grade 6* provide examples of how to engage students in higher-level, problem-solving and minds-on inquiry and investigation techniques.

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MODEL CURRICULUM GRADE 6

PHYSICAL SCIENCE (PS)

Topic: Matter and Motion

This topic focuses on the study of foundational concepts of the particulate nature of matter, linear motion, and kinetic and potential energy.

CONTENT STATEMENT

All matter is made up of small particles called atoms.

Each atom takes up space, has mass and is in constant motion. Mass is the amount of matter in an object.

Elements are a class of substances composed of a single kind of atom.

Molecules are the combination of two or more atoms that are joined together chemically.

Compounds are composed of two or more different elements. Each element and compound has properties, which are independent of the amount of the sample.

CONTENT ELABORATION

Prior Concepts Related to Matter

PreK-2: Properties are descriptions that can be observed using the senses. Materials can be sorted according to their properties. Changes in materials are investigated.

Grades 3-5: Objects are composed of matter, which has mass* and takes up space. Matter includes solids, liquids and gases (air). Volume is the amount of space an object takes up. The total amount of matter and mass* remains the same when it undergoes a change.

*While mass is the scientifically correct term to use in this context, the **NAEP 2009 Science Framework** (page 27) recommends using the more familiar term "weight" in the elementary grades with the distinction between mass and weight being introduced at the middle school level. In Ohio, students will not be assessed on the differences between mass and weight until Grade 6.

Grade 6 Concepts

All matter is made of atoms, which are particles that are too small to be seen, even with a light microscope. There is empty space between the atoms that make up a substance. An element is a chemical substance that cannot be broken down into simpler substances.

There are approximately 90 different naturally occurring elements that have been identified. There are additional elements that were made in a laboratory, but these elements are not stable. All atoms of any one element are alike, but are different from atoms of other elements.

All substances are composed of one or more of elements. Compounds are composed of elements joined together chemically. Each compound has its own unique, unchanging composition of type and number of elements and atoms. Both elements and compounds can form molecules (e.g., elemental hydrogen is made up of molecules containing two atoms of hydrogen joined together chemically, water is a compound made up of molecules containing two atoms of hydrogen joined with one atom of oxygen). In addition to molecules, atoms may join together in large three-dimensional networks (addressed further in high school). All particles of a pure substance have nearly identical mass. Particles of different substances usually have different masses, depending upon their atomic composition. Computer simulations can be used to visualize this abstract material.

Matter has properties of mass and volume. Mass measures the amount of matter in an object (e.g., a wood block) or substance (e.g., water), and volume measures the three-dimensional space that matter occupies. Equal volumes of different substances usually have different masses. Some materials, like lead or gold, have a lot of mass in a relatively small space. Other materials, like Styrofoam® and air, have a small mass in a relatively large amount of space. This concept of comparing substances by the amount of mass the substance has in a given volume is known as density.

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While the mass and volume of a material can change depending upon how much of the material there is, the density generally remains constant, no matter how much of the material is present. Therefore, density can be used to identify a material. The density of any object (e.g., a wood block) or substance (e.g., water) can be calculated from measurements by dividing the mass by the volume. Mass vs. volume graphs can be constructed and interpreted (e.g., to determine which material has the greater density.)

Note 1: Appropriate background knowledge such as graphics representing the atomic composition of the substances involved or descriptions of how the matter can be formed, decomposed or separated, should accompany questions asking to classify matter as an element, compound or mixture. The nature of chemical bonding is not appropriate at this grade.

Note 2: Constructing and analyzing mass vs. volume graphs aligns with fifth-grade common core mathematics standards (Geometry 1 and 2). The volume of solids can be determined by water displacement or calculated from the dimensions of a regular solid (grade 5 Common Core Mathematics Standards, Measurement and Data 5).

Note 3: The structure of the atom, including protons, neutrons and electrons, is addressed in the high school physical science syllabus.

Future Application of Concepts

Grades 7-8: Differences between pure substances and mixtures and acids and bases are explored. Elements in the periodic table can be classified as a metal, nonmetal or nonreactive gas based on their properties and position on the periodic table. Atoms can be joined together to form separate molecules or large three-dimensional networks. Changes are classified into two groups, chemical or physical, depending upon whether the atomic composition of the materials changes.

High School: Protons, neutrons and electrons make up atoms. The relationship between atomic structure and the periodic table is explored. The nature of ionic, covalent and metallic bonding is also studied.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning, and to develop summative assessment of student learning of science.

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS	DEMONSTRATING SCIENCE KNOWLEDGE	INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS	RECALLING ACCURATE SCIENCE
Use empirical evidence to construct an argument and defend a position.			
Evaluate the ratio of helium to air in party balloons and devise a claim referencing the behavior of molecules for the most cost-efficient and/or highest-performance (increased flotation, least leakage over time).	Use experimental data to investigate the behavior of atoms as a sample goes through three distinct phase changes (e.g., solid to liquid to gas). Measure the temperature and construct a graphical representation to aid in devising a plausible explanation for what happens during the phase changes.	Draw a model/pictorial representation that depicts the behavior of atomic particles for each state of matter (solid, liquid, gas). Explain the molecular motion for each state.	Describe the behavior of atomic particles for each state of matter (solid, liquid, gas).

INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- The Annenberg Media series **Essential Science for Teachers: Physical Science: Session 2**: *The Particle Nature of Matter* is a video on demand produced by Annenberg. It guides teachers through the essential concepts, includes student interviews that highlight common misconceptions and shows experiments and classroom instructional strategies that can be used to address these misconceptions.

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COMMON MISCONCEPTIONS

- **Gases do not have mass.**
- Mass and volume, which both describe an amount of matter, are the same property.
- Air and oxygen are the same gas.
- Particles of solids have no motion. Particles possess the same properties as the materials they compose. For example, atoms of copper are "orange and shiny," gas molecules are "transparent," and solid molecules are "hard."
- Particles are misrepresented in sketches with no differentiation between atoms and molecules.
- **Molecules of a gas just float** rather than being kept in the gaseous state by their motion.
- There is not empty space between molecules; rather students believe there is dust, germs or air between the particles of air.
- Although some students may think that substances can be divided up into small particles, they do not recognize the particles as building blocks, but as formed of basically continuous substances under certain conditions. Students of all ages show a wide range of beliefs about the nature and behavior of particles, including a lack of appreciation of very small size of particles. (AAAS 1993).
- Students often reason that because atoms are so small they have no mass. Several studies of students' initial conception of an atom show they perceive it as either "a small piece of material" or the "ultimate bit of material obtained when a portion of material is progressively subdivided." Such bits are thought to vary in size and shape and possess properties similar to the properties of the parent material. For example, some students consider atoms of a solid to have all or most of the macro properties that they associate with the solid, such as hardness, hotness/coldness, color and state of matter (Driver, Squire, Rushworth & Wood-Robinson, 1994, p. 74).
- **Essential Science for Teachers: Physical Science: Session 2**: *The Particle Nature of Matter* highlights different ideas that students have about matter, illustrated through interviews with students. The first half of the program shows how students can progress from a continuous model of matter to a model of matter that is made of discrete particles with nothing between them. It demonstrates activities to help students move from a continuous model to a particle model of matter. Notice that the real learning does not necessarily come from doing the activities, but from the discussions and questioning that occur after the experiences.

DIVERSE LEARNERS

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MODEL CURRICULUM GRADE 6

PHYSICAL SCIENCE (PS)

Topic: Matter and Motion

This topic focuses on the study of foundational concepts of the particulate nature of matter, linear motion, and kinetic and potential energy.

CONTENT STATEMENT

Changes of state are explained by a model of matter composed of atoms and/or molecules that are in motion.

When substances undergo changes of state, neither atoms nor molecules themselves are changed in structure.

Thermal energy is a measure of the motion of the atoms and molecules in a substance.

Mass is conserved when substances undergo changes of state.

Note: Thermal energy can be connected to kinetic energy at this grade level.

CONTENT ELABORATION

Prior Concepts Related to States of Matter

PreK-2: Properties can be observed and used to sort materials. Changes in materials are investigated, including solid-liquid phase changes.

Grades 3-5: Matter has mass* and volume. Properties of solids, liquids and gases, and phase changes are reversible and do not change the identity of the material. The total amount of matter remains the same when it undergoes a change. Mass* stays constant during phase changes.

*While mass is the scientifically correct term to use in this context, the **NAEP 2009 Science Framework** (page 27) recommends using the more familiar term "weight" in the elementary grades with the distinction between mass and weight being introduced at the middle school level. In Ohio, students will not be assessed on the differences between mass and weight until Grade 6.

Grade 6 Concepts

Thermal energy is the total amount of kinetic energy present in a substance (the random motion of its atoms and molecules). When thermal energy increases, the total kinetic energy of the particles in the system increases. The thermal energy of a substance depends upon the mass of the substance, the nature of the material making up the substance, and the average kinetic energy of the particles of the substance. Thermal energy cannot be directly measured; however, changes in thermal energy can be inferred based on changes in temperature. The higher the temperature of a particular substance, the greater the average kinetic energy and motion of the particles. Thermal energy depends on the amount of the substance, whereas temperature does not depend on the amount of the substance.

Solids, liquids and gases vary in the motion of and the spacing and attractions between particles. Solid particles are close together and held more rigidly in a space by the attractions between the particles. However, solid particles can still vibrate back and forth within this space. Liquid particles may be slightly farther apart but move with more speed than solid particles. In liquids, particles can move from one side of the sample to another. Gas particles are much farther apart and move with greater speed than liquid or solid particles. Because of the large spaces between the particles, gases are easily compressed into smaller volumes by pushing the particles closer together. Most substances can exist as a solid, liquid or gas depending on temperature. Generally, for a specific temperature, materials that exist as solids have the greatest attraction between the particles. Substances that exist as gases generally have the weakest attraction between the particles.

During phase changes, the mass of the substance remains constant because the particles (atoms and molecules) are not created or destroyed. There is simply a change in the motion of and spacing between the particles. Experiments and investigations (3-D and virtual) must be used to demonstrate phase changes.

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For substances to rearrange and form new substances, often the particles of the substances must first collide. The higher the temperature, the greater the average motion and the more likely the particles are to collide and rearrange to form new substances. In a solid, particles are rigidly held in fixed position. When the solid dissolves in water, the particles of the solid separate and move freely with the water particles. Therefore, particles in the dissolved state are more likely to collide with other particles and rearrange to form a new substance than they are as a solid.

Since moving atoms and molecules cannot be observed directly, provide the opportunity to experiment with temperature, phase changes and particle motion using virtual labs.

Note 1: Purdue University provides a table that can help in differentiating the properties of solids, gases and liquids.

Future Application of Concepts

Grades 7-8: Acids, bases, mixtures and pure substances are investigated. Elements are classified as metals, nonmetals or nonreactive gases based on their properties and position on the periodic table. Atoms can be joined together into separate molecules or large three-dimensional networks. Changes are classified as chemical or physical, depending upon whether the atomic composition of the materials changes.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning, and to develop summative assessment of student learning of science.

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS	DEMONSTRATING SCIENCE KNOWLEDGE	INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS	RECALLING ACCURATE SCIENCE
Use empirical evidence to construct an argument and defend a position.			
Evaluate the preparations of two remedies for an upset stomach, both containing the same medication in the same amount. One preparation involves a tablet to be chewed and swallowed. The other preparation involves a liquid to be swallowed. Ask: *Which preparation would provide the fastest relief and why?* Use data found on the Internet to support conclusions. Defend the reliability of research sources.	Develop and test a hypothesis about the behavior of three different states of matter in a closed retractable space (e.g., using a syringe, observe and record data when a solid, like a marshmallow, and a liquid is placed inside the chamber).	Explain in terms of the atomic theory why gases can be easily compressed, while liquids and solids cannot.	Match the properties of a state of matter with a picture of a sample representative of a specific state of matter.
		Explain how the arrangement of atoms determines the specific properties (e.g., compressibility, ability to take the shape of a container) of solids, liquids and gases.	Identify three states of matter.

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INSTRUCTIONAL STRATEGIES AND RESOURCES

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- The Phenomena and Representations for Instruction of Science in Middle Schools (**PRISMS**) website has a collection of representations to help students visualize atoms in a crystalline array. This website is part of the National Science Digital Library and also can be accessed through **http://nsdl.org**.
- **Changing State**, an interactive simulation from BBC Schools, allows students to heat and cool water and observe phase changes. The final section dealing with heating the gas further can be explained by the motion of the gas particles.
- From the series of videos on demand *Essential Science for Teachers: Physical Science* produced by Annenberg, the second part of **The Particle Nature of Matter**, starting at about 28:00, deals with differences in gases, liquids and solids and the idea that all particles are in motion. Notice the discussions and questioning strategies used to get students thinking at higher levels.
- The beginning of this segment of **Essential Science for Teachers: Physical Science**, produced by Annenberg, shows how the properties and changes of phases of matter can be explained with a particle model. Student interviews identify common misconceptions. Experiments and questioning strategies are shown that can guide students to a more accurate understanding of these concepts.
- **HMH School Publishers** sponsors this animation that shows the spacing and movement of particles in a solid, liquid and gas. This can be used with a student who needs more visualization than what static pictures in a book or on a chalkboard can provide.

COMMON MISCONCEPTIONS

- **Gases are not matter** because most are invisible.
- Gases do not have mass.
- A thick liquid has a higher density than water.
- Mass and volume, which both describe an amount of matter, are the same property.
- Air and oxygen are the same gas.
- Helium and hot air are the same gas.
- Expansion of matter is due to the expansion of particles, rather than the increased particle spacing.
- Particles of solids have no motion.
- Relative particle spacing among solids, liquids and gasses is incorrectly perceived and not generally related to the densities of the states.
- Materials can only exhibit properties of one state of matter.
- Melting/freezing and boiling/condensation are often understood only in terms of water.
- The smoke seen with dry ice is carbon dioxide vapor.
- The temperature of an object drops when it freezes.
- Steam is visible water gas molecules.
- **Melting and dissolving** are confused.
- Dew formed on the outside of glass comes from the inside of the glass.
- Molecules of a gas just float rather than being kept in the gaseous state by their motion.

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- From a time of about 27:50 to49:00 **this video on demand** produced by Annenberg, shows student interviews and classroom discussions that illustrate common misconceptions about evaporating, boiling and condensing. Strategies to address these misconceptions also are illustrated, including a series of experiments guiding students to construct an accurate particle model of matter that can explain the properties of gases and liquids and changes between them.
- Students regard powders as liquids and any non-rigid material, such as a sponge or a cloth as being somewhere in between a solid and a liquid.
- Students have difficulty recognizing the vibration of particles. (Driver, Squire, Rushworth & Wood-Robinson, 1994).
- Molecules and atoms disappear during burning, boiling and evaporation.
- *Science in Focus: Energy* produced by Annenberg is a series of videos on demand dealing with energy. **This segment deals with heat**. The video series is designed to make teachers aware of common student misconceptions. While not all concepts addressed are appropriate to be taught at this grade level, being aware of them can help avoid perpetuating common misconceptions.

DIVERSE LEARNERS

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CLASSROOM PORTALS

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Starting at about 42:30 of **Session 2: The Particle Nature of Matter** from the series *Essential Science for Teachers: Physical Science* produced by Annenberg, a teacher uses questioning strategies to discover where students think water goes after it rains. She brings out common experiences for them to consider and add to their explanations. Then the students are guided through a simple investigation to provide them with more information to develop their ideas. Later, a class is lead through activities and discussions to learn more about the movement of particles.

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MODEL CURRICULUM GRADE 6

PHYSICAL SCIENCE (PS)

Topic: Matter and Motion

This topic focuses on the study of foundational concepts of the particulate nature of matter, linear motion, and kinetic and potential energy.

CONTENT STATEMENT

There are two categories of energy: kinetic and potential.

Objects and substances in motion have kinetic energy.

Objects and substances can have energy as a result of their position (potential energy).

Note: Kinetic and potential energy should be introduced at the macroscopic level for this grade. Chemical and elastic potential energy should not be included at this grade; this is found in PS grade 8.

CONTENT ELABORATION

Prior Concepts Related to Energy

PreK-2: A variety of sounds and motions are experienced. The sun is the principal source of energy (ESS). Plants get energy from sunlight (LS).

Grades 3-5: Objects with energy have the ability to cause change. Heat, electrical energy, light, sound and magnetic energy are forms of energy. Earth's renewable and nonrenewable resources can be used for energy (ESS). All processes that take place within organisms require energy (LS).

Grade 6 Concepts

There are many forms of energy, but all can be put into two categories: kinetic and potential. Kinetic energy is associated with the motion of an object. The kinetic energy of an object changes when its speed changes. Potential energy is the energy of position between two interacting objects. Gravitational potential energy is associated with the height of an object above a reference position. The gravitational potential energy of an object changes as its height above the reference changes. Electrical energy is associated with the movement of electricity through the wires of an electrical device. Thermal energy refers to the total amount of kinetic energy a substance has because of the random motion of its atoms and molecules. Sound energy is associated with the back and forth movement of the particles of the medium through which it travels. Provide opportunities to explore many types of energy. Virtual experiments that automatically quantify energy can be helpful since using measurements to calculate energy is above grade level.

Note: Using the word "stored" to define potential energy is misleading. The word "stored" implies that the energy is kept by the object and not given away to another object. Therefore, kinetic energy also can be classified as "stored" energy. A rocket moving at constant speed through empty space has kinetic energy and is not transferring any of this energy to another object.

Future Application of Concepts

Grades 7-8: Conservation of Energy and methods of energy transfer, including waves, are introduced. Chemical and elastic potential energy are explored.

High School: Standard formulas are used to calculate energy for different objects and systems.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS	DEMONSTRATING SCIENCE KNOWLEDGE	INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS	RECALLING ACCURATE SCIENCE
Investigate energy transfers in a waterwheel.			
Design and build a system that uses water to cause a wheel to turn. Evaluate the designs from the class to determine which design features are most effective. Redesign the water wheel to incorporate best design practices.	Plan and implement a scientific experiment to determine the effectiveness of the water wheels produced by the class.	Outline the design by representing it pictorially and give an oral account of the function of each part of the design. Explain the reasons for design decisions. Graphically represent the data collected from the experiment. Compare the design features of effective and ineffective designs.	Classify the energy at each stage in the design as kinetic, potential or a combination of the two.
Investigate the relationship between height and gravitational potential energy.			
	Plan and implement a scientific experiment to determine the relationship between height and gravitational potential energy using **this interactive simulation.** Analyze the data to determine patterns and trends. Formulate a conclusion about the relationship between height and gravitational potential energy.	Represent the data graphically. Support the conclusion with evidence from the experiment.	Recognize that increasing height increases gravitational potential energy.
		Outline and explain the energy changes involved in dropping a book on the floor.	Recall that an object can have potential energy due to its position relative to another object and can have kinetic energy due to its motion.

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INSTRUCTIONAL STRATEGIES AND RESOURCES

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- The **simulation** at the bottom of this site from the University of Oregon Department of Physics allows students to change the mass and height of different spheres and see the changes in gravitational potential energy.

COMMON MISCONCEPTIONS

- **Things use up energy.**
- Energy is confined to some particular origin, such as what we get from food or what the electric company sells.
- An object at rest has no energy.
- The only type of potential energy is gravitational.
- Energy is a thing.
- The terms "energy" and "force" are interchangeable.

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MODEL CURRICULUM GRADE 6

PHYSICAL SCIENCE (PS)

Topic: Matter and Motion

This topic focuses on the study of foundational concepts of the particulate nature of matter, linear motion, and kinetic and potential energy.

CONTENT STATEMENT

An object's motion can be described by its speed and the direction in which it is moving.

An object's position and speed can be measured and graphed as a function of time.

Note 1: This begins to quantify student observations using appropriate mathematical skills.

Note 2: Velocity and acceleration rates should not be included at this grade level; these terms are introduced in high school.

CONTENT ELABORATION

Prior Concepts Related to Forces and Motion

PreK-2: Sound is produced from vibrating motions. Motion is a change in an object's position with respect to another object. Forces are pushes and pulls that are necessary to change the motion of an object. Greater changes of motion for an object require larger forces.

Grades 3-5: The amount of change in movement of an object is based on the mass* of the object and the amount of force exerted. The speed of an object can be calculated from the distance traveled in a period of time.

*While mass is the scientifically correct term to use in this context, the **NAEP 2009 Science Framework** (page 27) recommends using the more familiar term "weight" in the elementary grades with the distinction between mass and weight being introduced at the middle school level. In Ohio, students will not be assessed on the differences between mass and weight until Grade 6.

Grade 6 Concepts

When speed is calculated from a distance measurement, the distance is always measured from some reference point. To describe more thoroughly the motion of an object, the direction of motion can be indicated along with the speed.

Experiments (inside and outside of the classroom) and creating/interpreting graphs must be used to investigate motion. Plotting position (vertically) and time (horizontally) can be used to compare and analyze motion. No motion is represented by a horizontal line. Fast motion is represented by steep lines and slow motion is represented by lines that are more gradual. The relative speeds and positions of different objects can be determined from comparing their position vs. time graphs. Position vs. time graphs should not be rules to memorize, but interpretations based on data-driven graphs. Motion detectors can be used to compare the resulting graphs from different types of motion.

Plotting the speed (vertical axis) and time (horizontal axis) allows for comparison and analysis of speed. One can determine the speed of an object at any given time or determine the time at which an object has a particular speed from reading a speed vs. time graph. No motion would be shown with a straight horizontal line on the horizontal axis. Constant speed would be represented with a straight line above or below the horizontal axis. The faster the motion, the farther away the line will be from the horizontal axis. Speeding up would be represented with a line moving away from the horizontal axis. Slowing down would be represented with a line moving toward the horizontal axis. Speed vs. time graphs should not be rules to memorize, but interpretations based on data-driven graphs.

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If a force on an object acts toward a single center, the object's path may curve into an orbit around the center. A sponge attached to the end of a string will travel in a circular path when whirled. The string continually pulls the sponge toward the center, resulting in circular motion.

Note 1: This content is a precursor to the introduction of vectors. Using the word "vector" and exploring other aspects of vectors are not appropriate at this grade.

Note 2: Constructing and analyzing motion graphs aligns with fifth-grade common core mathematics standards (Geometry 1 and 2). At this grade, interpretations of position vs. time graphs should be limited to comparing lines with different slopes to indicate whether objects are moving relatively fast, relatively slow or not moving at all. More complex interpretations of position vs. time graphs will be made at higher grade levels. At this grade, interpretations of speed vs. time graphs should be limited to differentiating between standing still, moving at a constant relatively fast speed, moving at a constant relatively slow speed, speeding up and slowing down. More complex interpretations of speed vs. time graphs will be made at higher grade levels.

Future Application of Concepts

Grades 7-8: The concept of fields is introduced to describe forces at a distance. The concept of force is expanded to include magnitude and direction.

High School: Acceleration is introduced. Complex problems involving motion in two-dimensions and free fall will be solved. Complex position vs. time graphs, velocity vs. time graphs, and acceleration vs. time graphs will be analyzed conceptually and mathematically with connections made to the laws of motion.

EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning, and to develop summative assessment of student learning of science.

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides examples of tasks that students may perform; this includes guidance for developing classroom performance tasks. It is not an all-inclusive checklist of what should be done, but is a springboard for generating innovative ideas.

DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS	DEMONSTRATING SCIENCE KNOWLEDGE	INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS	RECALLING ACCURATE SCIENCE
	Investigate constant-speed motion.		
	Ask a scientific question about the motion of an object that moves at constant speed. Plan and implement a scientific investigation to answer the question. Determine what data will be collected and what tools will be needed. Analyze the data to determine patterns and trends about objects that move with constant speed and objects that move with different constant speeds.	Graphically represent the data collected from an object moving at constant speed. Compare the position vs. time graphs for fast- and slow-moving objects.	Recognize that faster objects have steeper lines on position vs. time graphs and slower objects have less steep lines.
Given a mousetrap car, redesign it so it will move to reproduce a particular position vs. time graph. Test the design using a motion detector.	Identify what is changing and what is not changing for an object moving at constant speed. Justify the answer with references to a distance vs. time graph.	Describe an object's motion by tracing and measuring its position over time. Recognize that motion describes the change in the position of an object (characterized by speed and direction) as time changes.	Given the distance and time, calculate the average speed of an object.

INSTRUCTIONAL STRATEGIES AND RESOURCES

This section provides additional support and information for educators. These are strategies for actively engaging students with the topic and for providing hands-on, minds-on observation and exploration of the topic, including authentic data resources for scientific inquiry, experimentation and problem-based tasks that incorporate technology and technological and engineering design. Resources selected are printed or Web-based materials that directly relate to the particular Content Statement. It is not intended to be a prescriptive list of lessons.

- **The Moving Man** is an interactive simulation from PhET shows graphs for different types of motion.

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COMMON MISCONCEPTIONS

- Some students think that an object traveling at constant speed requires a force.
- Some students think that **time can be measured without establishing the beginning of the interval**. The location of an object can be described by stating its distance from a given point, ignoring direction.

DIVERSE LEARNERS

Strategies for meeting the needs of all learners including gifted students, English Language Learners (ELL) and students with disabilities can be found at **this site**. Resources based on the Universal Design for Learning principles are available at **www.cast.org**.

CLASSROOM PORTALS

These are windows into the classroom through webcasts, podcasts or video clips to exemplify and model classroom methods of teaching science using inquiry.

Greg demonstrates strategies for designing inquiry activities for sixth-grade students in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

Paul works with sixth-grade science students using activities that promote deeper learning in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

Jeff demonstrates strategies using problem-based activities for science instruction in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

Margarita demonstrates strategies for teaching high-quality science to non-English speaking students in grades 5-8 in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.