Ohio State Common Core Standards for Science
K – 8 TECHNOLOGY FOCUS

Kindergarten

CONTENT STATEMENT

Weather changes are long-term and short-term.

Weather changes occur throughout the day and from day to day. Air is a nonliving substance that surrounds Earth and wind is air that is moving. Wind, temperature and precipitation can be used to document short-term weather changes that are observable. Yearly weather changes (seasons) are observable patterns in the daily weather changes.

Instructional Strategies and Resources

- Weather measurements must be collected on a regular basis throughout the school year and then compared, explained and discussed each week and each month. At the end of the school year, a comparison can be made and seasons can be identified by the patterns that were measured throughout the year. Consistent review and questioning to deepen understanding are essential. Use **TECHNOLOGY** to compare classroom data to local data, study weather events, communicate and share data with other classrooms, and record classroom data.

CONTENT STATEMENT

The moon, sun and stars can be observed at different times of the day or night.

Changes in the position of the sun in the sky can be measured and recorded at different times during the school day. Observations also can be made **VIRTUALLY**. This data can be compared from month to month to monitor changes. Stars, groups of stars and different phases of the moon can be observed through books or **VIRTUALLY** and documented throughout the month. The names of the stars, constellations or moon phases are not appropriate for Kindergarten; only the changes in appearances and what can actually be observed are included. The moon also can be observed in the daylight, at times. Drawings, **PHOTOGRAPHS** or other graphics can be used to document student observations.

Demonstrating (either 3-D or **VIRTUAL**) and testing/experimenting (through kits or models) must be used to explain the changing positions (in the sky) of the sun, stars and moon. Review, question and discuss the demonstrations and observations to deepen understanding.

Designing Technological / Engineering Solutions using Science Concepts

- Experiment with shadows from the sun. Questions to explore include: *What happens to a shadow throughout the day? Can the length of a shadow be measured? How does the shape of the shadow change? Can shadows be made inside?* Use light bulbs, overhead projectors, **VIRTUAL** investigations or combinations of the above to explore inside shadows.

CONTENT STATEMENT

Living things are different from nonliving things.

The emphasis is to build a grade-appropriate understanding of what it means to be living, not to distinguish living and nonliving. Living things respond to stimuli. The responses described must be easy to observe (e.g., fish in an aquarium respond to a stimulus – food). Living things grow (e.g., plant seeds or seedlings and watch them grow). Observing plants growing toward a light source can lead to experiments and explorations of what happens when the plant is placed in a different place in the classroom (e.g., on the floor, in a closet, on a desk) or rotated 90 degrees. Some observations also can be done **VIRTUALLY**.

Animals need food; plants make their own food. Read grade-appropriate, non-fiction books to students or by students (e.g., picture books) that accurately describe the characteristics of living things found in Ohio. **TECHNOLOGY** also can be used to find **PHOTOGRAPHS** and stories or take **PHOTOGRAPHS** of living things in Ohio.

Instructional Strategies and Resources

- The Ohio Department of Natural Resources provides information about observing animals in the wild while promoting safety for children and wildlife.
- ODNR's Guide to Using Animals in the Classroom provides guidance, explains legally which organisms may be

collected and offers limited advice on the use of animals in the classroom.
- Ohio's Outdoor Bill of Rights provides information about outdoor education experiences available for children with summaries of research that support helping children reconnect with nature. Ohio's parks have a variety of trails, nature centers and yearly activities to provide opportunities to study living things in the natural environment.

CONTENT STATEMENT

Living things have physical traits and behaviors, which influence their survival.

Living things are made up of a variety of structures. Some of these structures and behaviors influence their survival.

Instructional Strategies and Resources

- Study the characteristics of the environment in which plants and animals thrive and see how they interact with one another. The Great Sunflower Project collects data on the number of wild bees found nationally. Sunflowers are grown to attract bees. Then a report is sent to the site sponsors stating the number of bees observed. Observe the growth of sunflowers and study their characteristics while observing how bees interact with the flowers. Children can then ask questions about what happens with the variation in the number of bees.
- The Ohio Department of Natural Resources provides information about observing animals in the wild. Have children observe the physical characteristics of plants and animals and determine how those traits are involved in each organism's survival. *How do animals capture prey? How do birds get insects from the tree? Why do some birds have webbed feet and others do not? Those birds that do have webbed feet live in what type of environment?*

CONTENT STATEMENT

Objects and materials can be sorted and described by their properties.

Objects can be sorted and described by the properties of the materials from which they are made. Some of the properties can include color, size and texture.

Instructional Strategies and Resources

- Sorting and Using Materials, an interactive **SIMULATION** from BBC Schools, allows children to test and sort common objects for their abilities to bend and to determine whether they are waterproof. Directions are read to the child when the speaker icon is clicked.
- Grouping and Changing Materials, an interactive **SIMULATION** from BBC Schools, has children sort objects according to the materials from which they are made. Directions are read to the child when the speaker icon is clicked.

CONTENT STATEMENT

Some objects and materials can be made to vibrate to produce sound.

Sound is produced by touching, blowing or tapping objects. The sounds that are produced vary depending on the properties of objects. Sound is produced when objects vibrate.

Designing Technological / Engineering Solutions using Science Concepts

- Investigate sounds made with homemade instruments. Use graphics (e.g., **DIGITAL PHOTOGRAPHS**, **VIRTUALLY** composed graphics) to represent the observations from the experiment.

Instructional Strategies and Resources

- *Sound and Hearing* is an interactive **SIMULATION** from BBC Schools that allows children to explore differences in sound. The directions can be read to the children by clicking on the speaker icons.

Allow children to make their own musical instruments and test the different sounds that they make.

Grade 1

CONTENT STATEMENT

The sun is the principal source of energy.

Sunlight warms Earth's land, air and water. The amount of exposure to sunlight affects the amount of warming or cooling of air, water and land.

Instructional Strategies and Resources

- There are many different ways to measure heating and cooling from sunlight. At the early elementary level, it is important to allow children to explore the causes of temperature changes in materials as it relates to the sun. Background information about solar heating and solar energy can help develop research questions to encourage experimentation and investigation.
- Using water, sun and wind to explore energy is recommended for early elementary children. While the term and definition of energy is not appropriate for grade 1, exploring, experimentation and observations of energy (e.g., seeing and feeling air and water movement, feeling heat from sunlight) are encouraged.

CONTENT STATEMENT

The physical properties of water can change.

These changes occur due to changing energy. Water can change from a liquid to a solid and from a solid to a liquid. Weather observations can be used to examine the property changes of water.

Grade 1 Concepts

- Water can be observed in lakes, ponds, streams, wetlands, the ocean and through weather events. Freezing and melting of water are investigated through measurements and observations using **TECHNOLOGY**, in the classroom or in a natural setting. Examining maps (**VIRTUAL** or 2-D) of Ohio, world maps or globes can illustrate the amount of Earth's surface that is covered in water and why it is important to learn about water.

Instructional Strategies and Resources

- The Ohio EPA has an education site that provides information about wetlands in Ohio. The relationship between water, wetlands and changing seasons is an excellent way to learn about changing properties of water through natural observation.

CONTENT STATEMENT

Living things have basic needs, which are met by obtaining materials from the physical environment.

Living things require energy, water and a particular range of temperatures in their environments.
Plants get energy from sunlight. Animals get energy from plants and other animals.
Living things acquire resources from the living and nonliving components of the environment.

Instructional Strategies and Resources

- The Toledo Zoo offers distance learning Life Science opportunities for animal adaptations. Children can begin to explore how animal traits play a role in survival.
- The Annenberg **MEDIA** series *Essential Science for Teachers: Life Science: Session 1: What is Life* provides background information about the basic needs of living things and provides classroom strategies for instruction.
- *What do they use for shelter?* The Ohio Department of Natural Resources **WEB** site also provides information about observing animals in the wild and promotes safety for children and wildlife.
- Explore various plant life in the local environment. Document the conditions that support the plant. Ask: *Is the area moist? Is it dry? Does it get lots of sun or shade? What other types of plants are in the area?* The physical characteristics and habitat requirements for native trees in Ohio can be found on the Ohio State Extension **WEB** site.

CONTENT STATEMENT

Living things survive only in environments that meet their needs.

Resources are necessary to meet the needs of an individual and populations of individuals. Living things interact with their physical environments as they meet those needs. Effects of seasonal changes within the local environment directly impact the availability of resources.

Designing Technological / Engineering Solutions using Science Concepts

- Explain, draw, journal and **PHOTO**graph what happens to local living and nonliving environments over the course

of a school year. If resources are not available to draw or **PHOTO**graph, seasonal **PHOTOGRAPHS** taken in Ohio can be found on the Ohio Department of Natural Resources **Web site**.
- Match pictures of local plants and animals to the environment in which they can be found.

Instructional Strategies and Resources

- The Great Backyard Bird Count is an opportunity to make observations, and collect and report data in a local environment to create a real-time snapshot of bird locations. Note the environmental conditions in the area when birds are spotted and when they migrate. Ask: *What do these environmental changes mean for the birds?*
- Cornell Lab of Ornithology sponsors a site to collect data for birds in the local environment by watching bird feeders to create a real-time snapshot of bird populations.
- Wildlife Watch is sponsored by the National Wildlife Federation. Students can identify and track plants and animals that are found locally and nationally.
- Information about the number of individuals spotted, pictures and personal stories can be recorded and shared on this site. Data can be used to determine what areas support what types of organisms and where organisms are thriving and barely surviving.
- *Near One Cattail: Turtles, Logs and Leaping Frogs* by Anthony D. Fredericks is a book resource recommended by the Ohio Resource Center and Americans for the Advancement of Science. The book can be used in conjunction with a host of activities for a nature study.

CONTENT STATEMENT

Properties of objects and materials can change.

Objects and materials change when exposed to various conditions, such as heating or freezing. Not all materials change in the same way.

Instructional Strategies and Resources

- *Kitchen Magician* is a game from PBS Kids that emphasizes how materials can change during cooking.

CONTENT STATEMENT

Objects can be moved in a variety of ways, such as straight, zigzag, circular and back and forth.

The position of an object can be described by locating it relative to another object or to the object's surroundings.
An object is in motion when its position is changing. The motion of an object can be affected by pushing or pulling. A push or pull is a force that can make an object move faster, slower or go in a different direction.

Instructional Strategies and Resources

- *Making Objects Move* provides a strategy that emphasizes an inquiry approach to teaching and learning about different motions of objects. It includes many questions for possible investigations that children can perform. The second part has an idea for a design project.
- *Force and Motion*, produced by Annenberg, is a series of **VIDEO**s designed for teachers to improve their knowledge of forces and motion and gives ideas for teaching the concepts to elementary learners. This particular segment demonstrates experiences with balls and inclined planes that can get first- grade children to observe movement and to make inferences about forces that start the balls moving.

Grade 2

CONTENT STATEMENT

The atmosphere is made up of air.

Air has properties that can be observed and measured. The transfer of energy in the atmosphere causes air movement, which is felt as wind. Wind speed and direction can be measured.

Concepts

- Monitoring weather changes using **TECHNOLOGY** (e.g., posting/sharing classroom data with other classes at the school or at other schools) can lead to review and questioning of data and evaluation of wind patterns that may be documented.
- Experiments, models (including **DIGITAL**/**VIRTUAL**) and investigations must be conducted to demonstrate the properties of air, wind and wind-related weather events. Questions, comparisons and discussions related to actual data and the analysis of the data is an important way to deepen the content knowledge.

Instructional Strategies and Resources

- Use everyday materials to allow students to experiment and make their own weather instruments. The process of testing and evaluating the instrument is even more important than the resulting product.
- Connecting students to current weather discoveries and events are ways to generate interest in the science behind the event. Accurate scientific articles and journals about weather, air, atmosphere and wind can help students relate what they are learning in the classroom to the world around them.

CONTENT STATEMENT

Water is present in the air.

Water is present in the air as clouds, steam, fog, rain, ice, snow, sleet or hail. When water in the air cools (change of energy), it forms small droplets of water that can be seen as clouds. Water can change from liquid to vapor in the air and from vapor to liquid. The water droplets can form into raindrops. Water droplets can change to solid by freezing into snow, sleet or hail. Clouds are moved by flowing air. Experiments and investigations that demonstrate the conditions required for condensation or evaporation to occur lead to a deeper understanding of these concepts. Appropriate tools and **TECHNOLOGY** (to observe, share results or to document data) is required. Relating the required conditions to actual observations (outside the classroom), collecting and documenting data, drawing conclusions from the data, and discussions about the findings must be included for

Instructional Strategies and Resources

- Providing specific examples that connect air temperature and changes in water prepares students for learning about the water cycle in later grades. Observing and experimenting with water and temperature (student-led exploration) strategies can help make this important connection. Though the water cycle itself should not be introduced at this grade level, the example illustrates how water gets into the atmosphere (evaporation) and then what happens when it is in the atmosphere (condensation).

CONTENT STATEMENT

Long- and short-term weather changes occur due to changes in energy.

Changes in energy affect all aspects of weather, including temperature, precipitation amount and wind.

Designing Technological / Engineering Solutions using Science Concepts

- Plan and implement an investigation to collect and measure wind-chill data (or data that calculates the “feels like” temperature in the summer by relating humidity levels and temperature). Compare local results with a different location in the U.S. and discuss the similarities/differences of the data and the possible reasons for the similarities and differences.

Instructional Strategies and Resources

- The National Center for Atmospheric Research provides support and educational materials for teachers and students to learn about the connection between the atmosphere and weather.
- *Science Now* is a free periodical science journal that details the latest atmospheric research for educators.

- Using scientifically accurate resources and data about the atmosphere and weather that is connected to Ohio can add relevancy and meaning to what is going on in the classroom. The Midwest Climate Center provides FAQs about weather and climate, on-going research projects and quality resources for elementary teachers.

CONTENT STATEMENT

Living things cause changes on Earth.

Living things function and interact with their physical environments. Living things cause changes in the environments where they live; the changes can be very noticeable or slightly noticeable, fast or slow.

Concepts

- The environment is a combination of the interactions between living and non-living components. Living things can cause changes in their environment, which can be observed. These interactions can cause changes in groups of living things and the physical environment. Conducting investigations (in nature or **VIRTUALLY**) to document specific changes and the results of the changes must be used to demonstrate this concept (e.g., moles tunneling in a lawn, beavers or muskrats building dams, plants growing in cracks of rocks). Maps or charts (**DIGITAL** or 2-D) can be used to document the location of specific types of living things found in the local area.

Instructional Strategies and Resources

- Design build and maintain a worm-composting bin. Journal changes in the system and make connections on what is happening in the bin to what is happening in nature.
- Design and maintain an ant farm. Journal changes in the system and make connections on what is happening in the ant farm to what is happening in nature.
- Explore a beaver's habitat in nature or through **MEDIA**. Document observations of the beaver's habitat. Encourage children to ask questions about the impact of the dam on the ecosystem. Ask: *How many other organisms are impacted by the presence of the dam? How does the dam impact the river or stream?*

CONTENT STATEMENT

Some kinds of individuals that once lived on Earth have completely disappeared, although they were something like others that are alive today.

Living things that once lived on Earth no longer exist; their basic needs were no longer met.

Content Elaboration

- Explore and compare a vast array of organisms, both extinct (e.g., Rugosa Coral, Sphenopsids) and extant (e.g., Brain Coral, Equisetum). Research and exposure should focus on the organism and its environment for both extinct and extant organisms. **PHOTOGRAPHS**, **VIDEO**, **Web site**s, books, local parks and museums can be used to visualize past environments and the organisms that lived in them.

Designing Technological / Engineering Solutions using Science Concepts

- For a procedure that can be altered for use by different grades, see http://geophysics.esci.keele.ac.uk/earthlearningidea/PDF/66_Trail- making.pdf.

Instructional Strategies and Resources

- The Ohio Department of Natural Resources provides a list of Ohio's extinct species. Specific information about sphenopsid fossils is contained in the article *Coal*. These organisms can be compared to organisms that are living today. Have children note the differences between the species and compare the differences in each environment.
- Explore organisms that once lived in Ohio and no longer exist. *National Geographic* provides an article on the find of a giant cockroach fossil in Ohio. The Field Museum and *Science Daily* provide a rich source of information on the relationship between mammoths and elephants.

CONTENT STATEMENT

Forces change the motion of an object.

Motion can increase, change direction or stop depending on the force applied.
The change in motion of an object is related to the size of the force.
Some forces act without touching, such as using a magnet to move an object or objects falling to the ground.

Instructional Strategies and Resources

- *Making Objects Move* from NetLinks provides a strategy that emphasizes an inquiry approach to teaching and learning about different motions of objects.
- *Science in Focus: Forces and Energy* produced by Annenberg, is part of a series of **VIDEO**s on demand to help teachers improve their content knowledge about forces and energy. This particular segment focuses on forces and how they are related to, yet different from, work and energy. While children do not study work and energy until later, knowledge of these concepts can help teachers avoid perpetuating misconceptions.
- *Magnets and Springs* is an interactive **SIMULATION** from BBC Schools that demonstrates two important concepts: change in motion depends on the amount of force, and some objects are attracted by magnets and others are not. The size of the magnet, the rotation of the magnet and the types of objects exposed to the magnet and the force that puts the magnet in motion can all be changed.
- *Pushes and Pulls* is an interactive **SIMULATION** from BBC Schools in which children can investigate the effects of pushes and pulls on motion.

Grade 3

CONTENT STATEMENT

Earth's nonliving resources have specific properties.

Soil is composed of pieces of rock, organic material, water and air and has characteristics that can be measured and observed. Rocks have unique characteristics that allow them to be sorted and classified. Rocks form in different ways. Air and water are nonliving resources.

Concepts

The characteristics of rocks and soil must be studied through sampling, observation and testing. This testing includes the ability of water to pass through samples of rock or soil and the determination of color, texture, composition and moisture level of soil. Measurable and observable characteristics of rocks include size and shape of the particles or grains (if present) within the rock, texture and color. Age- appropriate tools must be used to test and measure the properties. The characteristics of the rock can help determine the environment in which it formed. **TECHNOLOGY** can be used to analyze and compare test results, connect to other classrooms to compare data or share samples, and document the findings.

Instructional Strategies and Resources

- Conducting student-led experiments, research and investigations to test soil properties is an important way to allow students to explore and learn about all aspects of soil. The GLOBE Program provides examples, data and resources to test specific types of soil and soil properties for elementary students. There also are opportunities to connect to other classrooms and compare soil data.
- The Ohio Department of Natural Resources' Soil and Water Conservation Division provides resources and support to teach about soil and properties of soil to elementary students. This page provides examples of soil profiling, how to conduct soils tests and maps of local soils (including a ***WEB*** *Soil Survey* feature that allows students to locate the soil types in their own backyards or at their schools.
- The Soil Science Society of America provides information about soils, testing the properties of soil and what soil scientists do. It also provides links to educational resources for soils. There are numerous age-appropriate resources that can support the teaching of soils in the third-grade classroom.
- NASA developed a program called *Dr. Soil* that includes numerous references, resources and lab activities to help support the teaching of soil to young students.
- Encouraging student rock collections to create classroom sample sets can connect nature to the classroom. ODNR provides helpful resources and geologic maps that can be used to study landforms and surface geology of Ohio. The surface geology map can be used to determine the types of rocks that may be found in the local areas (near the school) and to assist in field collections or discussions. GeoFacts is another site within ODNR that provides geologic facts related to Ohio and ODNR's Hands on Earth Science program offers educational support in multiple areas of Earth Science, including rocks, water and soil.

CONTENT STATEMENT

Earth's resources can be used for energy.

Many of Earth's resources can be used for the energy they contain. Renewable energy is an energy resource, such as wind, water or solar energy, that is replenished within a short amount of time by natural processes. Nonrenewable energy is an energy resource, such as coal or oil, that is a finite energy source that cannot be replenished in a short amount of time.

Instructional Strategies and Resources

- To understand the relationship between energy and wind, the Texas Energy Conservation Office developed fact sheets and other resources for elementary students and teachers. There also are ideas for activities and projects, all related to renewable energy.
- The National Renewable Energy Laboratory provides links to elementary wind programs (like KidWind and Wind for Schools) and resources and support for teaching about wind and wind turbines. There is information about national challenges for building wind turbine models at different grade levels and links to learn about solar energy and the relationship of solar and wind energy.
- The National Energy Education Development Project provides **ONLINE** information about energy sources at the primary grades, offers free downloads of primary books, and supports the teaching of a variety of energy resources, inquiry-based labs and experiments.
- Hydrologic power basics (at the teacher level) can be found at the USGS **Web site**. This basic information can be adapted to an observational level for students in grade 3. Building simple water turbines can be a good way to

explore this renewable energy resource.

CONTENT STATEMENT

Some of Earth's resources are limited.

Some of Earth's resources become limited due to overuse and/or contamination. Reducing resource use, decreasing waste and/or pollution, recycling and reusing can help conserve these resources.

Instructional Strategies and Resources

- The National Institute of Environmental Health Sciences offers support for teaching about recycling, reducing waste and reusing materials for elementary- aged students. Sign up for a newsletter to keep abreast of current events related to reducing, reusing and recycling materials.
- The EPA provides educational resources for primary students pertaining to Earth's resources, including background information, project ideas, starting up school recycling programs, how to reduce material use, challenges/contests for student participation and recycling clubs for K-5 students.
- The Ohio Department of Natural Resources provides a recycling guide for Ohio with an explanation of what and how things can be recycled in Ohio.
- The Ohio EPA provides lists of educational projects and educational opportunities that address Earth's resources. The lists can be used as idea starters and for inquiry-based student projects and provide contact information for teacher training.
- NSTA provides learning modules called *SciPacks* that are designed to increase teacher content knowledge through inquiry-based modules. This module addresses Earth's Resources.
- The National Energy Education Development Project provides **ONLINE** information about energy sources at the primary grades, offers free downloads of primary books, and supports the teaching of a variety of energy resources, inquiry-based labs and experiments.
- Take a field trip to a local landfill, recycling center, factory/industry that makes materials such as glass or metal or go to a water treatment facility to learn about the cycling of materials from production to disposal. SWACO offers fieldtrips, as do many landfill facilities.

CONTENT STATEMENT

Offspring resemble their parents and each other.

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

Concepts

A considerable amount of animal behavior is directly related to getting materials necessary for survival (food, shelter) from the environment and that influences what an animal learns. The focus at this grade level is on examples provided through observation or stories of animals engaging in instinctual and learned behaviors. Some organisms have behavioral traits that are learned from the parent (e.g., hunting). Other behavior traits that are in response to environmental stimuli (e.g., a plant stem bending toward the light). At this grade level, the definition of either instinctual or learned behavior is not learned. The focus is on making observations of different types of plant and animal behavior. **TECHNOLOGY** (e.g., a **WEB**cam) can be used to observe animals in their natural or human-made environments.

Designing Technological / Engineering Solutions using Science Concepts

- The Smithsonian National Zoological Park states, "Environmental enrichment is the process of providing stimulating environments for Zoo animals in order for them to demonstrate their species-typical behavior, to allow them to exercise control or choice over their environment and to enhance their well- being." Find more about animal environment enrichment at http://nationalzoo.si.edu/SCBI/AnimalE nrichment/default.cfm.
- Use **WEB**cams to view animals in their natural habitat or simulated environments to observe and record physical characteristics of the animals as well as behavioral traits that are taught from parent to offspring. Falcon cams are used by the Ohio Department of Natural Resources and can be used for this study at http://ohiodnr.com/wildlife/dow/falcons/ Default.aspx.

Instructional Strategies and Resources

- Use **WEB**cams to view animals in their natural habitat or simulated environments to observe and record physical

characteristics of the animals as well as behavioral traits that are taught from parent to offspring. Falcon cams are used by the Ohio Department of Natural Resources and can be used for this study. The North American Bear Center and the International Wolf Center also have **WEB**cams that can be used to study animals in their habitat.

- The Annenberg **MEDIA** series *Essential Science for Teachers: Life Science: Session 3 and 4* provides information about how children can learn about the life cycles of animals and offers classroom footage to illustrate implementation.

CONTENT STATEMENT

Individuals of the same kind differ in their traits and sometimes the differences give individuals an advantage in surviving and reproducing.

Plants and animals have physical features that are associated with the environments where they live.
Plants and animals have certain physical or behavioral characteristics that improve their chances of surviving in particular environments.
Individuals of the same kind have different characteristics that they have inherited. Sometimes these different characteristics give individuals an advantage in surviving and reproducing.

Concepts

- Plants and animals that survive and reproduce pass successful features on to future generations. Some grade-appropriate organisms to study are plants (e.g., radishes, beans) and insects (e.g., butterflies, moths, beetles, brine shrimp). Comparisons can be made in nature or **VIRTUALLY**. Venn diagrams can be used to illustrate the similarities and differences between individuals of the same type.

Instructional Strategies and Resources

- *Smithsonian Biodiversity Science in the Classroom: Teach, Learn, Explore, Observe and Inquire* illustrates how to set up a meter square investigation so that children can conduct an investigation by documenting seasonal changes in their local area.
- Monarchwatch.org provides guidance on how to hatch and raise butterflies for classroom observations of the life cycle. Additional information about emergence cages also can be found on this site.
- The program One Species at a Time allows an **AUDIO** tour of the wonders of nature by examining a variety of life forms through stories and ways to hone backyard observation skills. This program is developed by the Encyclopedia of Life and Atlantic Public **MEDIA**.

CONTENT STATEMENT

Plants and animals have life cycles that are part of their adaptations for survival in their natural environments.

Over the whole earth, organisms are growing, reproducing, dying and decaying. The details of the life cycle are different for different organisms, which affects their ability to survive and reproduce in their natural environments.

Concepts

- Observation of the complete life cycle of an organism can be made in the classroom (e.g., butterflies, mealworms, plants) or **VIRTUALLY**. Hand lens, magnifying lenses, metric rulers and scales are some of the tools that can be used to question, explore and investigate the physical appearance of living things.
- When studying living things, ethical treatment of animals and safety must be employed. Respect for and proper treatment of living things must be modeled. For example, shaking a container, rapping on insect bottles, unclean cages or aquariums, leaving living things in the hot sun or exposure to extreme temperatures (hot or cold) must be avoided. The National Science Teachers Association (NSTA) has a position paper to provide guidance in the ethical use and treatment of animals in the classroom at http://**www**.nsta.org/about/positions/animals.aspx.

Designing Technological / Engineering Solutions using Science Concepts

- In the process of planning an investigation to study the life cycle of a butterfly, evaluate the design of three emergence cages. Evaluate each cage using scientific knowledge about the needs of butterflies. Using the information from the study, design and build an “improved” butterfly emergence cage. Learn more at http://monarchwatch.org/rear/cages.ht m.

Instructional Strategies and Resources

- Explore how organisms reproduce, grow and find shelter in habitats around the world. The National Geographic **Web site** for kids houses information about the life cycles of animals from around the world. The National Wildlife Federation features Ranger Rick, with links to a variety of different types of wildlife. Plants and animals are featured in their natural habitats and their life cycles can be explored though stories and pictures.
- The life cycle of organisms can be observed in the classroom or **VIRTUALLY** via The Children's Butterfly Site, the PEACHES Lady Bug Saves the Roses **Web site** or other grade-appropriate sources of information on the life cycle of organisms. These sites include local, national and international projects and interactive games that explore various organisms.
- Sessions 3 and 4 of the Annenberg **MEDIA** series *Essential Science for Teachers: Life Science* provide information about how children can learn about the life cycles of animals and offer classroom footage to illustrate implementation at http://**www**.learner.org/resources/series179.html.

CONTENT STATEMENT

All objects and substances in the natural world are composed of matter.

Matter takes up space and has mass.

Instructional Strategies and Resources

- *Essential Science for Teachers: Physical Science: Session 1: Matter*, a **VIDEO** on demand produced by Annenberg, explores the concept of matter with elementary children and teachers. The segment includes defining matter and exploring properties and states of matter. It incorporates interviews with children and classroom segments to identify common misconceptions and gives teaching strategies to address these misconceptions. While the segment on plasma is interesting, it is content beyond this grade level.

CONTENT STATEMENT

Matter exists in different states, each of which has different properties.

The most common states of matter are solids, liquids and gases.

Shape and compressibility are properties that can distinguish between the states of matter.

One way to change matter from one state to another is by heating or cooling.

Instructional Strategies and Resources

- *Essential Science for Teachers: Physical Science: Session 1: Matter*, a **VIDEO** on demand produced by Annenberg, explores the concept of matter with elementary children and teachers. The segment includes defining matter and exploring properties and states of matter. It incorporates interviews of children and classroom segments to identify common misconceptions and gives teaching strategies to address these misconceptions. While the segment on plasma is interesting, it is content beyond this grade level.
- *Solids and Liquids*, an interactive **SIMULATION** from BBC Schools, has children determine the melting point of different substances to observe the properties of liquids and solids.
- *Changing State* is an interactive **SIMULATION** from BBC Schools that allows students to heat and cool water and to observe phase changes.

CONTENT STATEMENT

Heat, electrical energy, light, sound and magnetic energy are forms of energy.

There are many different forms of energy. Energy is the ability to cause motion or create change.

Concepts:

- Investigations (3-D or **VIRTUAL**) must be used to demonstrate the relationship between different forms of energy and motion.

Instructional Strategies and Resources

- *Science in Focus: Energy* is a series of **VIDEO**s on demand produced by Annenberg to help teachers understand children's preconceptions about energy and what is important to understand about energy.

Grade 4

CONTENT STATEMENT

Earth's surface has specific characteristics and landforms that can be identified.

About 70 percent of the Earth's surface is covered with water and most of that is the ocean. Only a small portion of the Earth's water is freshwater, which is found in rivers, lakes and ground water.

Earth's surface can change due to erosion and deposition of soil, rock or sediment. Catastrophic events such as flooding, volcanoes and earthquakes can create landforms.

Concepts

- There are many different processes that continually build up or tear down the surface of Earth. These processes include erosion, deposition, volcanic activity, earthquakes, glacial movement and weathering.Beginning to recognize common la ndforms or features through field investigations, field trips, topographic maps, remote sensing data, aerial **PHOTOGRAPHS**, physical geography maps and/or **PHOTOGRAPHS** (through books or **VIRTUALLY**) are important ways to understand the formation of landforms and features. Common landforms and features include streams, deltas, floodplains, hills, mountains/mountain ranges, valleys, sinkholes, caves, canyons, glacial features, dunes, springs, volcanoes and islands.
- Connecting the processes that must occur to the resulting landform, feature or characteristic should be emphasized. This can be demonstrated through experiments, investigations (including **VIRTUAL** experiences) or field observations. **TECHNOLOGY** can help illustrate specific features that are not found locally or demonstrate change that occurred (e.g., using satellite **PHOTO**s of an erosion event such as flooding).

Designing Technological / Engineering Solutions using Science Concepts

- Research a specific weathering feature (such as a sinkhole or cave). Evaluate the risk of collapse and methods of prevention of collapse (using actual data) and recommend one solution based on the scientific data. Create a model (**VIRTUAL**, graphic or 3-D) of the actual cave or sinkhole and demonstrate the risk of collapse and how the suggested preventative measure or solution impacts that risk.

Instructional Strategies and Resources

- Fieldtrips to local caves, caverns, sinkholes, glacial areas, stream systems, lakes, etc., should be encouraged to experience Ohio geologic landforms and features first hand. There also are numerous **VIRTUAL** fieldtrips to visit caves, canyons, glaciers, mountains and valleys.
- The Ohio Department of Natural Resources provides helpful resources and geologic maps that can be used to study landforms and surface geology of Ohio. The relationship between the types of rocks and the resulting features or landforms is a very important connection, especially if local/regional maps are used in conjunction with field trips or outside investigations around the community or school property.
- Viewing landforms and surface geology from satellite **PHOTOGRAPHS** and through remote sensing can be a helpful tool in illustrating landforms in different parts of the world and conditions that exist for formation. Click on the geographical features icon to see satellite **PHOTO**s of Earth's surface.
- The NASA Visible Earth Program houses hundreds of satellite **PHOTO**s that can be used to illustrate specific landforms. Comparing the **PHOTO** to a map can be a good way to learn about recognizable features such as delta systems, mountain ranges, volcanoes and canyons.
- The National Atlas mapmaker site can plot areas within the United States where specific geologic features are found. For example, by clicking on *Geology*, then the *Karst, Engineering Aspects* option, areas that have caves, caverns and sinkholes are shown. This can be a good starting resource to locate other maps, **PHOTO**s and graphics related to landforms and features that form through erosion and/or deposition.
- The USGS **Web site** provides data, information, books and maps that relate to Earth's surface, weathering and erosion. Many of these resources are free and some are available at cost.
- The National Speleological Society provides information and resources for caves and caving for young students. Taking a field trip to an Ohio cave connects what is learned in the classroom about weathering and erosion to the real world. It is essential to learn about the processes of cave formation and karts topography, including lab investigations, to prepare students for a cave or cavern field experience.

CONTENT STATEMENT

The surface of Earth changes due to weathering.

Rocks change shape, size and/or form due to water or ice movement, freeze and thaw, wind, plant growth, gases in the air, pollution and catastrophic events such as earthquakes, mass wasting, flooding and volcanic activity.

Concepts

Different types of rock weather at different rates due to specific characteristics of the rock and the exposure to weathering factors (e.g., freezing/thawing, wind, water). Weathering is defined as a group of processes that change rock at or near Earth's surface. Some weathering processes take a long time to occur, while some weathering processes occur quickly. The weathering process must be observed in nature, through classroom experimentation or **VIRTUALLY**. Seeing tree roots fracturing bedrock or the effect of years of precipitation on a marble statue can illustrate ways that rocks change shape over time. Investigations can include classroom **SIMULATION**s, laboratory testing and field observations.

Designing Technological / Engineering Solutions using Science Concepts

Research a specific weathering feature (e.g., sinkhole, cave). Evaluate the risk of collapse and methods of prevention of collapse (using actual data) and recommend one solution based on the scientific data. Create a model (**VIRTUAL**, graphic or 3-D) of the actual cave or sinkhole and demonstrate the risk of collapse and how the suggested preventative measure or solution impacts that risk.

Instructional Strategies and Resources

- It is important for students to understand the difference between weathering and erosion, as well as how the two processes work together to form geologic features.
- **ONLINE** geologic museum sites can offer examples and data for studying rates of weathering and different types of weathering. Testing the weathering rate of a variety of substances can help in the understanding that some things may take a long time to weather and others a short time.
- The USGS provides weathering-rate data for a variety of rocks and types of soil. This data can help teachers determine types of materials that weather at a rate that could be observed in a classroom setting).

CONTENT STATEMENT

The surface of Earth changes due to erosion and deposition.

Water, wind and ice physically remove and carry (erosion) rock, soil and sediment and deposit the material in a new location.Gravitational force affects movements of water, rock and soil.

Concepts

Erosion is a "destructive" process and deposition is a "constructive" process. Erosion and deposition directly contribute to landforms and features formation that are included in grade 4. Topographic maps and aerial **PHOTOGRAPHS** can be used to locate erosional and depositional areas in Ohio. Surficial geology maps also can illustrate the patterns of glacial erosion and deposition that have occurred. Field trips and field investigations (may be **VIRTUAL**) are recommended as erosional and depositional features that can be seen locally or within the state can help to connect the concept of erosion and deposition to the real world.

Designing Technological / Engineering Solutions using Science Concepts

- Use actual geologic data from a specific location, such as the Grand Canyon. Research the formation of the canyon. Ask: *Why does some rock weather and erode faster than others? What caused the weathering and erosion in the canyon? How can the age of the canyon be estimated?*
- Use the research data to make a geologic cross section (3-D or **VIRTUAL** model or a graphic) to model the canyon.

Instructional Strategies and Resources

- The USGS and the National Park Service provide explanations about how erosion and weathering are different processes, but often work together. This is a good site to assist teachers in preparing to teach about weathering and erosion.
- The Ohio Department of Natural Resources provides resources and information about Ohio's surface geology, including surficial geology maps of Ohio that show glacial patterns in Ohio very clearly.
- Understanding Ohio's glacial history and the different glacial periods will help middle school students prepare for understanding the geologic history of Ohio. This **Web site** includes a discussion of specific resultant landforms that can be seen today. Showing **PHOTOGRAPHS** of the landforms and connecting

- them to maps, drawings or historical stories connects to the real world. Taking a field trip to view a landform in person can be a culminating experience.
- The Ohio EPA provides basic background information about sediment contamination and control issues within Ohio. There are **VIDEO** clips of actual sediment-control measures and problems. This is a good starting point for the design section (classroom example) listed above.

CONTENT STATEMENT

Changes in an organism's environment are sometimes beneficial to its survival and sometimes harmful.

Ecosystems can change gradually or dramatically. When the environment changes, some plants and animals survive and reproduce and others die or move to new locations. An animal's patterns of behavior are related to the environment. This includes the kinds and numbers of other organisms present, the availability of food and resources, and the physical attributes of the environment.

Concepts

Researching and investigating specific areas in Ohio (e.g., Cedar Bog, Lake Erie, Hocking Hills, Ceasar Creek, Kellys Island) via field studies, **VIRTUAL** field trips or other references must be used to explore the relationships between previous environments, changes that have occurred in the environments and the species that lived there.

Designing Technological / Engineering Solutions using Science Concepts

- Critique plans (written or oral) from different organizations to reintroduce a species into an Ohio environment. Write a newspaper article in support or against the reintroduction of the species based upon scientific facts. Find more information at http://**www**.clemetzoo.com/rttw/swan/al labt.htm.
- Describe the im**MEDIA**te consequences of rapid ecosystem change for organisms within an ecosystem and describe the consequences this change will have on an ecosystem a decade or more later (e.g., flooding, wind storms, snowfall, volcanic eruptions).
- Research a major geologic event (e.g., Mt. St. Helens volcanic eruption, tsunami). Develop a timeline depicting the environment before the event, immediately after the event and in designated time intervals until a stable community is established (e.g., 30 or more years). Find information at http://**www**.fs.fed.us/gpnf/mshnvm/edu cation/teachers-corner/library/life- returns01.shtml#01.

Instructional Strategies and Resources

- One example is the trumpeter swan. The Ohio History Central and Cleveland Metropolitan Zoo provide details of this bird's story.
- The **VIRTUAL** Nature Trail at Penn State New Kensington is an opportunity to observe **PHOTO**s of various species of plants interacting with one another and the environment and examine what changes result due to those interactions.
- Citizen Science is program promoted by the National Wildlife Federation to have the public volunteer time to assist scientists in their wildlife research by collecting data, sharing experiences and spreading valuable information. Wildlife can be monitored and the changes that occur in the ecosystem can be monitored and analyzed.

CONTENT STATEMENT

Fossils can be compared to one another and to present-day organisms according to their similarities and differences.

The concept of biodiversity is expanded to include different classification schemes based upon shared internal and external characteristics of organisms.

Most types of organisms that have lived on Earth no longer exist.

Fossils provide a point of comparison between the types of organisms that lived long ago and those existing today.

Designing Technological / Engineering Solutions using Science Concepts

- From observation of fossils in rock layers, infer the environmental conditions that existed when the fossils were formed (e.g., fish fossils would indicate a body of water existed at the time the fossils formed). For more information visit http://**www**.ohiohistorycentral.org/subc ategory_topic.php?c=NH&s=GEOL&t= FOSS.
- Identify evidence that can be used to determine the existence of an organism. For more information, visit http://**www**.ucmp.berkeley.edu/educati on/explorations/tours/intro/Introkto4b/to ur1nav.php
- Observe fossils and compare them to similar plants and animals that live today, using simple classification schemes. For more information, visit

http://www.ucmp.berkeley.edu/education/explorations/tours/stories/middle/C3.html.

Instructional Strategies and Resources

- The University of Berkeley **Web site** Understanding Evolution can provide teachers with content knowledge on the topic of evolution. This site provides detailed information from various research projects about how fossils provide evidence of climate changes.
- The University of Berkeley's *Stories from the Fossil Record, Past Lives* provides information on how fossils provide information on the behavior of organisms (family and social) as well as how certain features of organisms came to be. Observe fossils and compare them to similar plants and animals that live today, using simple classification schemes. The Ohio History Central provides a list of fossils found in Ohio.
- National Geographic's movie Sea Monsters provides an opportunity to go on a **VIRTUAL** fossil dig and explore organisms that lived a long time ago but are similar to organisms that are alive today.
- Life Has a History, produced by the University of California Museum of Paleontology, illustrates the similarities and differences between living things that exist today and organisms that lived in the past. It is a simple introduction to the fossil record.
- Session 6 of the Annenberg **MEDIA** series *Essential Science for Teachers: Life Science* provides information about how children can learn about the variations of living things that lead to evolution and offers classroom footage to illustrate implementation at http://www.learner.org/resources/series179.html.

CONTENT STATEMENT

The total amount of matter is conserved when it undergoes a change.

When an object is broken into smaller pieces, when a solid is dissolved in a liquid or when matter changes state (solid, liquid, gas), the total amount of matter remains constant.

Instructional Strategies and Resources

- *Keeping Warm*, an interactive **SIMULATION** from BBC Schools, allows students to measure temperature changes over time for different insulating materials.
- *Melting and Freezing* from Science NetLinks gives an example of using inquiry to explore the mass of water, margarine and chocolate chips before and after melting. To extend this, students can put the substances in the refrigerator or freezer to reform the solid and find the mass again.

CONTENT STATEMENT

Energy can be transformed from one form to another or can be transferred from one location to another.

Energy transfers from hot objects to cold objects as heat, resulting in a temperature change. Electric circuits require a complete loop of conducting materials through which an electrical energy can be transferred. Electrical energy in circuits can be transformed to other forms of energy, including light, heat, sound and motion. Electricity and magnetism are closely related.

Instructional Strategies and Resources

- *Electrical Conductors*, an interactive **SIMULATION** from BBC Schools, allows students to explore different materials and classify them as electrical conductors or insulators. It also emphasizes that a complete loop of conductors is needed for a circuit to be complete.
- *Electricity in a Brown Bag* from eGFI gives examples of how to use inquiry to teach the basic concepts of electricity safely using readily available materials. Using bulb sockets such as these available from many vendors, allow students to trace the flow of electricity from the wires through the bulb. Students also can try to light the bulb without the socket.
- Career Corner from EIA Energy Kids has several articles that give information about different careers in energy.
- *Coffee Can Speakers: Amazing Energy Transformers* is an article from the March 2007 issue of *Science and Children* that gives instructions on how to make a simple speaker to demonstrate the transformation of energy and the relationship between electricity and magnetism. Once the speaker is made and understood, students can be challenged to make changes to the system to improve the sound from the speakers.

Grade 5

CONTENT STATEMENT

The solar system includes the sun and all celestial bodies that orbit the sun. Each planet in the solar system has unique characteristics.

The distance from the sun, size, composition and movement of each planet are unique. Planets revolve around the sun in elliptical orbits. Some of the planets have moons and/or debris that orbit them. Comets, asteroids and meteoroids orbit the sun.

Instructional Strategies and Resources

- Ensuring that relevant and up-to-date information about the solar system is important. NASA's **Web site** offers a good starting point with helpful resources, references, content-specific data for the solar system, recent research and discoveries to help teachers prepare to teach about the solar system.
- Science News for Kids is a resource that provides topics and current events that include new discoveries and research related to the solar system and space. These articles can help form classroom discussions and research ideas for students.
- The University of Chicago provides ideas and background for student projects related to the solar system and solar exploration. One project combines science and investigation through the role of a reporter. Students collaborate and learn about asking investigative questions. By presenting the science material in a different format, students of all ability levels can be engaged in learning.
- NSTA provides learning modules called *SciPacks* that are designed to increase teacher content knowledge through inquiry-based modules. This module addresses the Earth, moon and sun.
- Life on Mars is an example of a student research idea that helps with understanding properties. Using real planetary characteristics and sizes can make the research authentic.
- Helping students understand the distances within the solar system and the size of the solar system can be difficult. Using student-made scaled models of the solar system (based on actual data) can develop that understanding. Information about historic discoveries and events as related to the solar system can be located at the NASA **Web site**.

CONTENT STATEMENT

The sun is one of many stars that exist in the universe.

The sun appears to be the largest star in the sky because it is the closest star to Earth. Some stars are larger than the sun and some stars are smaller than the sun.

Concepts

The sun is the closest star to the Earth. Scaled models (3-D or **VIRTUAL**) and graphics can be used to show the vast difference in size between the sun and the Earth. The sun is a medium-sized star and is the only star in our solar system. There are many other stars of different sizes in the universe. Because they are so far away, they do not appear as large as the sun.

Instructional Strategies and Resources

- NASA provides background data about the sun (including recent discoveries, research and **PHOTO**s) to help teachers prepare for teaching about the sun.
- NSTA provides learning modules called *SciPacks* that are designed to increase teacher content knowledge through inquiry-based modules. This module addresses the sun as a star.
- It can be difficult for fourth-grade students to understand the size and scale of the solar system. Setting up scaled models (e.g., making the classroom into the solar system using actual distance data) or investigating the solar system by setting up a planetarium can increase understanding. It is important to use student inquiry and investigation in developing the models.
- New **TECHNOLOGY** and discoveries are important to include in learning about the sun and the solar system. Projects such as NASA's Solar Orbiter or the Solar Probe Plus can be used in classroom discussions to engage student interest and ensure that new findings are part of the curriculum.
- Mission Science provides games and activities for students that can supplement what is being learned in the classroom and generate interest. The **COMPUTER** games are interactive and based on accurate science.

CONTENT STATEMENT

Most of the cycles and patterns of motion between the Earth and sun are predictable.

Earth's revolution around the sun takes approximately 365 days. Earth completes one rotation on its axis in a 24-hour period, producing day and night. This rotation makes the sun, stars and moon appear to change position in the sky. Earth's axis is tilted at an angle of 23.5°. This tilt, along with Earth's revolution around the sun, affects the amount of direct sunlight that the Earth receives in a single day and throughout the year. The average daily temperature is related to the amount of direct sunlight received. Changes in average temperature throughout the year are identified as seasons.

Concepts

- Models, interactive **Web site**s and investigations are required to illustrate the predictable patterns and cycles that lead to the understanding of day and night, seasons, years and the amount of direct sunlight Earth receives. Three-dimensional models should be used to demonstrate that the tilt of Earth's axis is related to the amount of direct sunlight received and seasonal temperature changes.

Instructional Strategies and Resources

- The National Atlas mapping project provides maps that show areas within the United States that are effective in generating solar energy. This can be a starting resource for the Designing Solutions section listed in the classroom examples.
- Using specific data to determine the actual distances and sizes of objects within the solar system is an important part of understanding Earth's role in the solar system. The characteristics of the Earth and the relationship of the rotation and orbit of Earth and the seasons are all related to the cycles within the solar system.
- Modeling the movement within the solar system and the resultant moon and moon phases is important in understanding the processes required. Names of the lunar phases are not the emphasis; the processes and positions of the sun, Earth and moon during the phases should be the focus.
- Collecting background information about how direct sunlight is actually measured and using the direct sunlight data to understand weather and solar energy are important. NASA provides information for the teacher about how direct sunlight measurements are collected.

CONTENT STATEMENT

Organisms perform a variety of roles in an ecosystem.

Populations of organisms can be categorized by how they acquire energy. Food webs can be used to identify the relationships among producers, consumers and decomposers in an ecosystem.

Instructional Strategies and Resources

- NSTA offers a content-rich segment for ecosystem study. Coral Reef Ecosystems: Interdependence develops understanding of the interactions and energy flow between organisms in a food web.

CONTENT STATEMENT

All of the processes that take place within organisms require energy.

For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred and transformed by producers into energy that organisms use through the process of photosynthesis. That energy then passes from organism to organism as illustrated in food webs. In most ecosystems, energy derived from the sun is transferred and transformed into energy that organisms use by the process of photosynthesis in plants and other photosynthetic organisms.

Concepts

- It is important that the ecological role of organisms is interwoven with a clear understanding that all living things require energy. **VIRTUAL SIMULATION**s and investigations can help demonstrate energy flow through the trophic levels.
- Satellite imaging, remote sensing or other **DIGITAL**-research formats can be used to help visualize what happens in an ecosystem when new producers (e.g., Tamarisk plants) are introduced into an ecosystem. The information gained should be used to determine the relationship between the producers and consumers within an ecosystem.

Instructional Strategies and Resources

- The Annenberg **MEDIA** series *Essential Science for Teachers: Life Science: Session 7* provides information about

populations of organisms that live and interact together. The focus is on the process of energy flow between producers, consumers and decomposers.

CONTENT STATEMENT

The amount of change in movement of an object is based on the mass of the object and the amount of force exerted.

Movement can be measured by speed. The speed of an object is calculated by determining the distance (d) traveled in a period of time (t). Earth pulls down on all objects with a gravitational force. Weight is a measure of the gravitational force between an object and the Earth. Any change in speed or direction of an object requires a force and is affected by the mass* of the object and the amount of force applied.

Concepts:

- Movement is measured by speed (how fast or slow the movement is). Speed is measured by time and distance traveled (how long it took the object to go a specific distance). Speed is calculated by dividing distance by time. Speed must be investigated through testing and experimentation. Real-world settings are recommended for the investigations when possible. **VIRTUAL** investigations and **SIMULATION**s also can be used to demonstrate speed.
- Speed must be explored and tested through investigations (3-D or **VIRTUAL**) inside and outside of the classroom. **VIDEO TECHNOLOGY** can be used to stop movement and measure changes at different steps in the investigations.

Designing Technological / Engineering Solutions using Science Concepts

Instructional Strategies and Resources

- Forces and movement, an interactive **SIMULATION** from BBC Schools, gives students the chance to try different forces and weights to see how the movement of a car is changed.

CONTENT STATEMENT

Light and sound are forms of energy that behave in predictable ways.

Light travels and maintains its direction until it interacts with an object or moves from one medium to another and then it can be reflected, refracted or absorbed. Sound is produced by vibrating objects and requires a medium through which to travel. The rate of vibration is related to the pitch of the sound.

Concepts:

- Light can be absorbed by objects, causing them to warm. How much an object's temperature increases depends on the material of the object, the intensity of and the angle at which the light striking its surface, how long the light shines on the object and how much light is absorbed. Investigating and experimenting with temperature changes caused by light striking different surfaces can be **VIRTUAL** or in a lab setting.
- Pitch can be changed by changing how fast an object vibrates. Objects that vibrate slowly produce low pitches; objects that vibrate quickly produce high pitches. Audible sound can only be detected within a certain range of pitches. Sound must travel through a material (medium) to move from one place to another. This medium may be a solid, liquid or gas. Sound travels at different speeds through different **MEDIA**. Once sound is produced, it travels outward in all directions until it reaches a different medium. When it encounters this new medium, the sound can continue traveling through the new medium, become absorbed by the new medium, bounce back into the original medium (reflected) or engage in some combination of these possibilities.
- Light travels faster than sound. **TECHNOLOGY** and **VIRTUAL SIMULATION**s and models can help demonstrate movement of light and sound. Experimentation, testing and investigation (3-D or **VIRTUAL**) are essential components of learning about light and sound properties.

Instructional Strategies and Resources

- The Utah Education Network shows how to construct lenses out of lemon Jell-O® that could be used for inquiry activities dealing with light for schools with limited resources.
- *How We See Things*, an interactive **SIMULATION** from BBC Schools, allows students to explore the path light takes with different orientations of mirrors. Students place mirrors in different locations with different orientations to alter the path of light to hit a target.
- *Changing Sounds*, an interactive **SIMULATION** from BBC Schools, demonstrates the differences between pitch

and loudness and allows students to experiment with different ways to change the pitch and loudness of different types of sounds from a guitar.

- *Light and Dark*, an interactive **SIMULATION** from BBC Schools, allows students to experiment with the differences between objects that can be seen because they give off light and objects that can be seen because they reflect light.
- *Seeing the Light* is an article from the December 2009 issue of *Science and Children*. It proposes that teaching the concepts of light from a **PHOTO**n model is more concrete for upper-elementary students than teaching from a wave model. It includes descriptions of how common light phenomena can be explained using a **PHOTO**n model.

Grade 6

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.

Designing Technological / Engineering Solutions using Science Concepts

- 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.

Instructional Strategies and Resources

- 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 **Web site**'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.
- NASA/CSU Partners in Education provides mineral information and mineral identification support for middle school teachers and students. Basic mineral information is provided regarding mineral properties, mineral formation and specific tests that can be conducted to identify minerals.
- 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.

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).

Instructional Strategies and Resources

- NASA/CSU Partners in Education provides support for teaching about igneous and metamorphic rock formation, conditions and processes that must exist, and methods to identify specific types of igneous and metamorphic rocks.
- 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.

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.

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.

Instructional Strategies and Resources

- *incorporate **TECHNOLOGY** and **TECHNOLOGICAL*** 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 **Web site** also can be used to help prepare students to make their own geologic maps of their local communities.
- Teaching about the relationship between different rock types and the conditions and processes that must occur to form specific types of rock allows students to understand the interpretation of the geologic rock record. NASA/CSU Partners in Education provides support for teaching about igneous and metamorphic rock formation, conditions and processes that must exist, and methods to identify specific types of igneous and metamorphic rocks.
- 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.

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.

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. 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.

Designing Technological / Engineering Solutions using Science Concepts

- 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.

Instructional Strategies and Resources

- 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.
- 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.

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.

Instructional Strategies and Resources

- 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.

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.

All cells come from pre-existing cells.

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

Instructional Strategies and Resources

- 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.
- 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.

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.

Concepts

- 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 **SIMULATION**s to investigate specific outcomes and develop predictions about changes in functions.

CONTENT STATEMENT

Living systems at all levels of organizationdemonstrate 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.

Instructional Strategies and Resources

- Wisc-**ONLINE** offers an interactive opportunity to xamine an animal cell and learn about the functions of its organelles.

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.

Concepts

- 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 SIMULATION**s can be used to visualize this abstract material.

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.

Concepts

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

Instructional Strategies and Resources

- The Phenomena and Representations for Instruction of Science in Middle Schools (PRISMS) **Web site** has a collection of representations to help students visualize atoms in a crystalline array. This **Web site** 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.

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).

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.

Designing Technological / Engineering Solutions using Science Concepts

- 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**.

Instructional Strategies and Resources

- 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.

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.

Instructional Strategies and Resources

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

Grade 7

CONTENT STATEMENT

The hydrologic cycle illustrates the changing states of water as it moves through the lithosphere, biosphere, hydrosphere and atmosphere.

Thermal energy is transferred as water changes state throughout the cycle. The cycling of water in the atmosphere is an important part of weather patterns on Earth. The rate at which water flows through soil and rock is dependent upon the porosity and permeability of the soil or rock.

Concepts

The movement of water in the cycle also can move contamination through each of the spheres. Relating water flow to geographic and topographic landforms and/or features leads to an understanding of where water flows and how it moves through the different spheres. Topographic and aerial maps (can be **VIRTUAL**) can be used to identify drainage patterns and watersheds that contribute to the cycling of water. Lab investigations or **TECHNOLOGY** can be used to simulate different segments of the hydrologic cycle.

Instructional Strategies and Resources

- Ground water is often overlooked or minimalized in the teaching of the hydrologic cycle. It is important to discuss and demonstrate the distribution of Earth's water to show that there is more ground water than surface water. The National Ground Water Association offers information, data and resources to support teachers in teaching all aspects of ground water.
- The USGS provides resources, data, information, books and maps that relate to Earth's resources and the hydrologic cycle.
- Contamination can be introduced at all steps of the hydrologic cycle. This relationship is important to begin to show how contamination migrates and travels between Earth's spheres. The Ohio EPA provides background and resource information related to water and water contamination issues related
- to the hydrologic cycle. It also includes helpful environmental education resources. Other related programs include Project Wet and ODNR's Division of Soil and Water Resources.
- **ITUNES** provides free *Science Quest* **VIDEO** clip downloads that address current discoveries pertaining to water, research and events. These can generate topics of interest, research ideas and discussion points for the class.
- Using recent discoveries and **TECHNOLOGY** are ways to interest and engage students by connecting to real events that are directly related to water contamination and water shortage problems. Satellite imagery can show specific contamination issues that are relevant to Ohio (e.g., algae contamination within drinking water supplies) and can be used for research and comparative studies in the classroom.
- Healthy Water, Healthy People offers ideas and resources for teaching all aspects of water and water contamination issues. Ideas for field monitoring and research projects, as well as investigative projects for students, are found within the program. Teacher training is included.
- Connecting the hydrologic cycle (and other biogeochemical cycles) with everyday life and experiences is essential since many resources and references regarding cycles within Earth systems are very abstract and difficult to apply to the real world. Choosing local issues that involve water and conducting field studies and research about the movement of water and/or contamination can lead to deeper understanding of how the cycles work (e.g., researching acid mine drainage problems in southeastern Ohio. The Monday Creek **Web site** provides research and data for southeastern Ohio and acid mine drainage cleanup efforts. There are other resources listed on the site to assist in student research.

CONTENT STATEMENT

Thermal-energy transfers in the ocean and the atmosphere contribute to the formation of currents, which influence global climate patterns.

The sun is the major source of energy for wind, air and ocean currents and the hydrologic cycle. As thermal energy transfers occur in the atmosphere and ocean, currents form. Large bodies of water can influence weather and climate. The jet stream is an example of an atmospheric current and the Gulf Stream is an example of an oceanic current. Ocean currents are influenced by factors other than thermal energy, such as water density, mineral content (such as salinity), ocean floor topography and Earth's rotation. All of these factors delineate global climate patterns on Earth.

Designing Technological / Engineering Solutions using Science Concepts

- Investigate water using drifter and student-built buoys. *Buoys are used by scientists to collect water data on a continual basis or to collect data in areas where sampling may be difficult. Drifter buoys are ocean buoys that are equipped with sensors that can transmit data (e.g., water temperature, air temperature, location) via satellites.*
- Based on the interpretation and analysis of drifter buoy data (), develop a list of criteria (including cost) for successful buoy deployment and life span.
- Design, build and test a buoy that can sample water temperatures or another water-quality test (e.g., pH, turbidity levels) of a local lake, pond, pool or stream. Deploy the buoy and collect/analyze data. Compare and discuss results with the class. Find additional information about buoys under Instructional Strategies and Resources.
- Analyze real-time drifter buoy data to determine the pattern of the Gulf Stream. Compare the present pattern with documented seasonal patterns over a five-year period. Using quantifiable data, outline factors that contribute to the changing patterns and influence the Gulf Stream.
- Additional buoy data is available at NOAA Drifter Buoy Program.
- Represent the oceanic data on a graph or chart to assist in the analysis and interpretation found under .
- Identify the factors that contribute to the global climate.

Instructional Strategies and Resources

- NOAA provides an opportunity for students to track free-floating buoys (linked via GPS/Satellite systems) to actually see the movement of oceanic currents over time. The buoys also collect surface temperature and barometric pressure data that relate to climate and weather changes. Training CDs are available to assist and support teachers in the implementation of the real-time buoy data.
- Have students build their own buoys out of everyday materials (e.g., PVC piping) to collect data from local water systems (e.g., streams, ponds, lakes, pools). Test and deploy the buoys. NOAA offers information about student-built buoys. Research Ohio water-quality buoy data, such as real-time Lake Erie data from moored buoy stations. The stations are monitored daily, which enables students to compare and analyze data on a long-term basis. Buoy building also offers a strong connection to STEM education.
- Building large ships or models and then evaluating the design using research and investigation can generate interest for many students. Hosting a culminating contest or participating in regional contests can further engage students in learning about ship design and effectiveness. Competitions at the middle school level for large boat events and combinations of large and small boat competitions can help in planning.
- Building a Remotely Operated Vehicle to collect specified data within a marine environment allows students to explore the engineering field while supporting scientific concepts and investigations directly related to deep and shallow oceanic currents, tides, waves and new scientific discoveries.

CONTENT STATEMENT

The atmosphere has different properties at different elevations and contains a mixture of gases that cycle through the lithosphere, biosphere, hydrosphere and atmosphere.

The atmosphere is held to the Earth by the force of gravity. There are defined layers of the atmosphere that have specific properties, such as temperature, chemical composition and physical characteristics. Gases in the atmosphere include nitrogen, oxygen, water vapor, carbon dioxide and other trace gases. Biogeochemical cycles illustrate the movement of specific elements or molecules (such as carbon or nitrogen) through the lithosphere, biosphere, hydrosphere and atmosphere.

Designing Technological / Engineering Solutions using Science Concepts

- Using ozone data from the stratospheric level, generate a graph that illustrates the changes in the ozone over a specific period of years.

Instructional Strategies and Resources

- The Ohio EPA's Division of Air Pollution Control provides resources, data and information pertaining to air and air pollution. The home page of this site also offers environmental education resources that can be used in the classroom.
- To understand fully the properties of the atmosphere and the different layers, a connection between density and chemical properties must be provided.
- This is found in PS grade 6. Interpreting actual data to identify the different layers of the atmosphere can help in this connection between physical and chemical properties of the atmosphere. Background data to help support the teaching of the atmosphere should include chemistry, composition, temperature, pressure and density.

- Learning about air quality and air-quality issues within the United States and within Ohio can increase awareness of the importance of conserving air as a resource. NOAA provides air-quality information and actual data that can be used in the classroom. AirOhio is another helpful site that concentrates on the air quality within Ohio and offers a database that houses regional monitoring data for specific air-quality parameters.

CONTENT STATEMENT

The relative patterns of motion and positions of the Earth, moon and sun cause solar and lunar eclipses, tides and phases of the moon.

The moon's orbit and its change of position relative to the Earth and sun result in different parts of the moon being visible from Earth (phases of the moon). A solar eclipse is when Earth moves into the shadow of the moon (during a new moon). A lunar eclipse is when the moon moves into the shadow of Earth (during a full moon). Gravitational force between the Earth and the moon causes daily oceanic tides. When the gravitational forces from the sun and moon align (at new and full moons) spring tides occur. When the gravitational forces of the sun and moon are perpendicular (at first and last quarter moons), neap tides occur.

Concepts

- The role of gravitational forces and tides are introduced in relationship to the position of the Earth, moon and sun. Models and **SIMULATION**s (can be 3-D or **VIRTUAL**) must be used to demonstrate the changing positions of the moon and Earth (as they orbit the sun) and lunar/solar eclipses, daily tides, neap and spring tides, and the phases of the moon.

Instructional Strategies and Resources

- Allowing students to observe and document changes in tides or lunar phases and then recreating the observation in the classroom can be useful in teaching patterns and cycles within the solar system. Often **VIRTUAL** demonstrations (repeated as needed) can help students that may be struggling in understanding the relationship of gravity and neap/spring tides or other cycles and patterns.

CONTENT STATEMENT

In any particular biome, the number, growth and survival of organisms and populations depend on biotic and abiotic factors.

Biomes are regional ecosystems characterized by distinct types of organisms that have developed under specific soil and climatic conditions. The variety of physical (abiotic) conditions that exists on Earth gives rise to diverse environments (biomes) and allows for the existence of a wide variety of organisms (biodiversity). Ecosystems are dynamic in nature; the number and types of species fluctuate over time. Disruptions, deliberate or inadvertent, to the physical (abiotic) or biological (biotic) components of an ecosystem impact the composition of an ecosystem.

Instructional Strategies and Resources

- Research a biome by monitoring changes in the biotic and abiotic factors of the ecosystem. Have students ask questions about how the habitat has changed over a given period of time (abiotic factors). Ask: *How have those changes impacted living things?* Select an organism and find data on the population. Determine what changes have occurred in that population and provide scientific reasons for those changes. Ask: *What efforts have been employed to protect the population?* WWF for a living planet has resources, data, reports and activities about the health of the world's biomes. NSTA Sci- Links, Missouri Botanical Garden, Freshwater Ecoregions of the World and the World Wildlife Organization provides information and data about the biomes of the world.
- The program One Species at a Time allows an **AUDIO** tour of the wonders of nature by examining a variety of species around the world through stories.
- Conduct an interactive lab designed to build your own ecosystem and explore the interrelationships between biotic and abiotic factors and their changes.
- Play interactive games to help students become aware of the variety of organisms that exist in the world.
- The **VIRTUAL** Nature Trail at Penn State New Kensington is an opportunity to observe **PHOTO**s of various species of plants interacting with one another and the environment and examine what changes result due to those interactions.

CONTENT STATEMENT

The properties of matter are determined by the arrangement of atoms.

Elements can be organized into families with similar properties, such as highly reactive metals, less- reactive metals, highly reactive nonmetals and some gases that are almost completely nonreactive. Substances are classified according to their properties, such as metals and acids. When substances interact to form new substances, the properties of the new substances may be very different from those of the old, but the amount of mass does not change.

Instructional Strategies and Resources

- *Essential Science for Teachers* is a series of **VIDEO**s on demand produced by Annenberg. The segment *Physical Changes and Conservation of Matter* integrates high-quality content information with exemplary classroom practices that primarily address conservation of matter as it relates to change. The **VIDEO** shows that some physical changes are reversible. Please be advised that not all physical changes are reversible and that the differentiation of change as "chemical" or "physical" is inappropriate.
- *Essential Science for Teachers* is a series of **VIDEO**s on demand produced by Annenberg. The segment *Chemical Changes and Conservation of Matter* integrates high-quality content information with exemplary classroom practices that primarily address conservation of matter as it relates to change. The **VIDEO** shows that some chemical changes cannot be reversed. Please be advised that not all chemical changes are irreversible and that the differentiation of change as "chemical" or "physical" is inappropriate.
- The Periodic Table of **VIDEO**s from the University of Nottingham contains short **VIDEO**s of all the elements. **VIDEO**s include what the element looks like in elemental form, some of the reactions of the element and the uses for the element.

CONTENT STATEMENT

Energy can be transformed or transferred but is never lost.

When energy is transferred from one system to another, the quantity of energy before transfer equals the quantity of energy after transfer. When energy is transformed from one form to another, the total amount of energy remains the same.

Designing Technological / Engineering Solutions using Science Concepts

- Investigate energy transformations in a roller coaster. Design and construct a roller coaster so that a marble will travel over a track that involves at least three hills. Apply the Law of Conservation of Energy to the roller coaster design. Make a series of bar graphs that show kinetic energy, potential energy and thermal energy for eight different positions on the roller coaster. Place each set of bar graphs on a different index card for each position and shuffle the cards. Switch index cards and roller coaster designs with another group in the class. Organize the index cards in the correct order for the coaster. Recognize that energy can change forms but the total amount of energy remains constant.
- Investigate energy transformations for a skateboarder. Plan and implement a scientific experiment to explore energy transformations for a skateboarder using the *Skate Park* **SIMULATION**. The program can track changes in different types of energy over time. Analyze the data to determine patterns and trends. Formulate a conclusion about energy transformations. Share the results with the class. Summarize the experiment in writing. Graphically represent the energy of the skateboarder during a run. Use the results from different groups in the class to compare different designs to the energy graphs. Support the conclusion with experimental evidence.

Instructional Strategies and Resources

- *Energy Skate Park,* an interactive **SIMULATION** from PhET, demonstrates conservation of energy.
- *The Ultimate Roller Coaster Contest* from Discovery Education gives an idea for a design project that demonstrates energy transformation.
- *Rube Goldberg™ Invention* from PBS Kids gives ideas for design projects that accomplish a simple task using many steps and energy transfers.

CONTENT STATEMENT

Energy can be transferred through a variety of ways.

Mechanical energy can be transferred when objects push or pull on each other over a distance.
Electromagnetic waves transfer energy when they interact with matter.
Thermal energy can be transferred through radiation, convection and conduction.
Electrical energy transfers when an electrical source is connected in a complete electrical circuit to an electrical device.

CONCEPTS

- Investigations and experiments (3-D and **VIRTUAL**) must be used to connect energy transfer and waves to the natural world. Real data must be used, such as oceanic or seismic wave data or light and sound wave data.
- Heat is thermal energy transferred between objects and travels from a warm object to a cooler one, unless additional energy is used. Thermal energy can be transferred when moving atoms collide. This is called conduction. Thermal energy also can be transferred by means of thermal currents in air, water or other fluids. As fluids are heated, they expand, decreasing the density. Warmer material with less density rises, while cooler material with a greater density sinks, causing currents that transfer energy in a process called convection. Thermal energy also can be transformed into waves that radiate outward. This energy transferred by the waves can be transformed back into thermal energy when it strikes another material through a process called radiation. **TECHNOLOGY** (e.g., **VIRTUAL SIMULATION**s, satellite imagery, remote sensing, accessing real-time temperature data) can be used to demonstrate the transfer of thermal energy on the surface or interior of Earth and within the solar system.
- An electric circuit exists when an energy source (e.g., battery, generator, solar cell) is connected to an electrical device (e.g., light bulb, motor) in a closed circuit. The energy source transfers energy to charges in the circuit. Charges flow through the circuit. Electric potential is a measure of the potential electrical energy of each charge. Differences in voltages can be measured with a voltmeter. The energy source does not create the charges; they were already present in the circuit. When the charges reach an electrical device, energy can be transformed into other forms of energy (light, sound, thermal or mechanical). The voltage drops after this energy transfer, but the charges continue to move through the circuit. In an open circuit, the charges stop flowing and energy is not transferred. Current is the rate of charge flow through conductors and can be measured with an ammeter. The degree to which current is opposed in a circuit is called resistance. Generally, for a particular energy source, the greater the resistance, the lower the current. The resistance through a wire depends upon the type of metal, the length of the wire and the diameter of the wire. Electrical devices can be connected in a series or as a parallel circuit. As the number of devices in a series loop increases, the current in the loop decreases. In a parallel circuit, the currents in each loop are the same as they would be if each loop were the only loop in the circuit. Testing and experimenting (3-D or **VIRTUALLY**) with electrical circuits to evaluate the energy transfers, resistance, current and changes in voltage are required.

Instructional Strategies and Resources

- Circuit Construction Kit (DC only) is an interactive **SIMULATION**

CONTENT STATEMENT

The composition and properties of Earth's interior are identified by the behavior of seismic waves.

The refraction and reflection of seismic waves as they move through one type of material to another is used to differentiate the layers of Earth's interior. Earth has an inner and outer core, an upper and lower mantle, and a crust.
The formation of the planet generated heat from gravitational energy and the decay of radioactive elements, which are still present today. Heat released from Earth's core drives convection currents throughout the mantle and the crust.

Concepts

- It is important to provide the background knowledge regarding how scientists know about the structure and composition of the interior of Earth (without being able to see it). Seismic data, graphics, charts, **DIGITAL** displays and cross sections must be used to study Earth's interior. Actual data from the refraction and reflection of seismic waves can be used to demonstrate how scientists have determined the different layers of Earth's interior. New discoveries and **TECHNOLOGICAL** advances relating to understanding Earth's interior also play an important role in this content.

Instructional Strategies and Resources

- Building a working seismograph can be a way of combining design and engineering with understanding earthquakes and waves within science. Relating earthquakes to actual movements of the Earth can be difficult if the student has not actually experienced it. Using a seismograph and interpreting seismic data from working seismographs can help demonstrate the movement. Teach Engineering resources include information on building a seismograph. There also are specific resources to the engineering and design process and how to use them with eighth-grade students. Other examples of building a seismograph are available **ONLINE**. It is important to allow the student to test and experiment with the instrument to develop an understanding of how it measures Earth movement.
- The USGS provides helpful background data that connects the structure of Earth to plate tectonics. There also are links provided to show real-time seismic data (including data for the state of Ohio) and interactive seismic maps that can be manipulated.
- Another way to engage and interest students in the study of the structure of Earth and seismic activity is through specific case studies and research (e.g., the Denali Fault Earthquake of 2002). Showing the actual seismic waves as they travel can help students see the actual results of a real earthquake.

CONTENT STATEMENT

Earth's crust consists of major and minor tectonic plates that move relative to each other.

Historical data and observations such as fossil distribution, paleomagnetism, continental drift and sea-floor spreading contributed to the theory of plate tectonics. The rigid tectonic plates move with the molten rock and magma beneath them in the upper mantle. Convection currents in the crust and upper mantle cause the movement of the plates. The energy that forms convection currents comes from deep within the Earth. There are three main types of plate boundaries: divergent, convergent and transform. Each type of boundary results in specific motion and causes events (such as earthquakes or volcanic activity) or features (such as mountains or trenches) that are indicative of the type of boundary.

Concepts

Physical world maps, cross sections, models (**VIRTUAL** or 3D) and data must be used to identify plate boundaries, movement at the boundary and the resulting feature or event. The relationship between heat from Earth's core, convection in the magma and plate movement should be explored. World distribution of tectonic activity of possible interest should be investigated (e.g., Ring of Fire, San Andreas Fault, Mid- Atlantic Ridge, Mariana Trench, Hawaiian Islands, New Madrid Fault System).

Designing Technological / Engineering Solutions using Science Concepts

- Investigate, using magnetic data from new **TECHNOLOGY** and the rock record, the pattern of reversing magnetism within Earth's core. Generate a chart or graph to represent findings. Using historical data, predict a time range for when the next reversal could occur. Share findings with the class and be prepared to discuss what impact the reversal could have for humans.
- Using a world map, mark the locations of all earthquakes and volcanoes that are recorded each week for one

month (or longer). Use a different color or pattern so that earthquakes and volcanoes can be differentiated. Outline the boundaries of where the concentrations are located. Compare/contrast this map with a map of plate boundaries. Ask: *What types of boundaries are found in the volcano areas? What types are found in earthquake areas?* Discuss findings with the class.

Instructional Strategies and Resources

- To grasp plate movement fully, students must investigate Earth's history using real data and maps. Maps constructed using scientific evidence, such as Earth's magnetism and sea floor spreading, can be helpful. Interpreting paleomagnetic data for different geologic periods demonstrates how scientists determine plate movement over time.
- Another way to show plate movement and emphasize the evidence from the geologic record is to use **TECHNOLOGY** and **VIRTUAL** field trips. Seeing the impact and movement of the plates firsthand can help with understanding the dynamic and changing features of Earth.
- Showing each geologic time period and the location of the major plates through time can help illustrate the ever-changing surface of Earth. Comparing
- tectonic maps from the earliest time period to present day and then predicting where the plates will be in the future can deepen the understanding of these processes.
- NSTA provides learning modules called *SciPacks* that are designed to increase teacher content knowledge through inquiry-based modules. This module addresses Plate Tectonics.
- Constructing geologic maps from actual data allows students to document evidence in a unique way. Maps can be compared and be used to discuss the changes that occur in specific locations. The National Association of Geoscience Teachers provides inquiry-based activities and resources for constructing geologic maps to demonstrate plate tectonics.
- The USGS provides helpful background data to understand the relationship between the structure of Earth and plate tectonics.

CONTENT STATEMENT

A combination of constructive and destructive geologic processes formed Earth's surface.

Earth's surface is formed from a variety of different geologic processes, including but not limited to plate tectonics.

Instructional Strategies and Resources

- Constructing geologic maps from actual data allows students to document evidence in a unique way. Maps can be compared and used to discuss the changes that occur in specific locations. The National Association of Geoscience Teachers provides inquiry-based activities and resources for constructing geologic maps to demonstrate plate tectonics.
- The USGS provides helpful background data to understand constructive and destructive Earth processes as related to plate tectonics.
- Students should be able to look at topographic maps, geologic maps and aerial **PHOTOGRAPHS** to identify constructive and destructive features found in Ohio, the United States and other areas of the world. Comparing and contrasting the features and the processes that created the features increase the
- depth of student understanding. ODNR demonstrates the dynamic surface of Earth through interactive and geologic maps specific to Ohio. There are many other resources that help support the teaching of geology using surficial maps to view the changing, dynamic surface of the Earth.
- The relationship between plate movement and the interior of Earth should be demonstrated through a variety of different resources (e.g., maps, **PHOTOGRAPHS**, **VIRTUAL** experiences, film clips of constructive and destructive processes, study of Earth systems). The **DIGITAL** Library for Earth Systems
- Education offers resources from a number of sources (e.g., *National Geographic*, government agencies, scientific agencies). An inquiry example can show how to integrate the study of plate tectonics, seismic waves and earthquakes with constructive and destructive processes.

CONTENT STATEMENT

Evidence of the dynamic changes of Earth's surface through time is found in the geologic record.

Earth is approximately 4.6 billion years old. Earth history is based on observations of the geologic record and the understanding that processes observed at present day are similar to those that occurred in the past (uniformitarianism). There are different methods to determine relative and absolute age of some rock layers in the geologic record. Within a

sequence of undisturbed sedimentary rocks, the oldest rocks are at the bottom (superposition). The geologic record can help identify past environmental and climate conditions.

Concepts

- Using actual data to generate geologic maps of local or statewide formations can connect to the real world. Field studies or geologic research (can be **VIRTUAL**/**DIGITAL**) can help identify local formations and interpret the environment that existed at the time of the formation.

Designing Technological / Engineering Solutions using Science Concepts

- Using **TECHNOLOGY**, investigate the geologic record **VIRTUALLY** to collect data and conduct scientific investigations through 60-70 million years of geologic time. Analyze data and document all changes verified by the data. Discuss conclusions and findings with the entire class.
- Choose a specific geologic time period and location on Earth that has geologic rock record data. Represent the geologic time period graphically (using **TECHNOLOGY** or manually). Include specific formation information. Share the final product with the class.

Instructional Strategies and Resources

- The USGS provides helpful background data to understand the relationship between the structure of Earth, the history of Earth and plate tectonics. It is important to use actual geologic time data and ensure that absolute time is fully explained. Timeline activities (e.g., using a football field for the timeline with an inch equaling one million years) may enhance class discussions.
- Relating the geologic record to Ohio is another strategy that can increase student engagement. Allow students to interpret Ohio's geologic history by combining field observations, bedrock geology maps and scientific research and data. ODNR offers a number of references and resources to help interpret Ohio geologic history.
- In addition to the geologic record, ice cores can be used to determine environmental conditions that existed at the time of formation. Actual ice-core data should be used. Interpretations of the data can support student ideas and discussions. **VIRTUAL** field experiences and film clips can add to student interest.

CONTENT STATEMENT

Reproduction is necessary for the continuation of every species.

Every organism alive today comes from a long line of ancestors who reproduced successfully every generation. Reproduction is the transfer of genetic information from one generation to the next. It can occur with mixing of genes from two individuals (sexual reproduction). It can occur with the transfer of genes from one individual to the next generation (asexual reproduction). The ability to reproduce defines living things.

Concepts

- In sexual reproduction, a single specialized cell from a female (egg) merges with a specialized cell from a male (sperm). Typically, half of the genes come from each parent. The fertilized cell, carrying genetic information from each parent, multiplies to form the complete organism. The same genetic information is copied in each cell of the new organism. In sexual reproduction, new combinations of traits are produced which may increase or decrease an organism's chances for survival. Investigations and experimentation (3-D or **VIRTUAL**) must be used to compare offspring to parents in sexual and asexual reproduction.

Instructional Strategies and Resources

- Teachers' Domain: Reproduction is an **ONLINE** activity in which students explore the various ways that organisms reproduce.
- Teachers' Domain: Reproduction and Genetics is a two-session course that explores the cellular processes that organisms use to develop, reproduce and pass traits from one generation to the next.

CONTENT STATEMENT

Diversity of species occurs through gradual processes over many generations. Fossil records provide evidence that changes have occurred in number and types of species.

Fossils provide important evidence of how life and environmental conditions have changed.
Changes in environmental conditions can affect how beneficial a trait will be for the survival and reproductive success of an

organism or an entire species.
Throughout Earth's history, extinction of a species has occurred when the environment changes and the individual organisms of that species do not have the traits necessary to survive and reproduce in the changed environment. Most species (approximately 99 percent) that have lived on Earth are now extinct.

Instructional Strategies and Resources

- The Annenberg **MEDIA** series *Essential Science for Teachers: Life Science: Session 5* provides information on how children can learn about the variations of living things and offers classroom footage to illustrate implementation. Conduct an investigation to study adaptations of organisms and how they affect survival in a particular environment. Bottle biology offers a methodology for this investigation.
- The Missouri Botanical Garden helps students explore the world's biomes and their organisms. When students choose a biome or ecosystem, they discover a wide variety of information on plants, animals and their habitats.

CONTENT STATEMENT

The characteristics of an organism are a result of inherited traits received from parent(s).

Instructional Strategies and Resources

- DNA from the Beginning explores aspects of Mendel's genetic experiments with animations. The Law of Segregation, the Law of Independent Assortment and the Law of Dominance are explained.
- The University of Utah's Genetic Learning Center offers *Tour of the Basics*, a tutorial that contains animations to explain heredity and its components. For this content area, focus on *What is Heredity?* and *What is a Trait?* Some areas of this site go beyond the scope of this grade-level content.
- The Canadian Museum of Nature's section called The GEEE! in Genome offers foundational information for heredity. Click on *The Basics* and then
- *Heredity and Reproduction* for activities to support the understanding of genetics.
- Teachers' Domain: Reproduction and Genetics is a two-session course that explores the cellular processes that organisms use to develop, reproduce and pass traits from one generation to the next.

CONTENT STATEMENT

Forces between objects act when the objects are in direct contact or when they are not touching.

Designing Technological / Engineering Solutions using Science Concepts

- Investigate the affect of charges and distance on electrical forces. Using the **SIMULATION** titled *Coulomb's Law,* plan and implement a scientific investigation to determine the relationship between either distance and force or charge and force for two charges. Recognize that the electrical force decreases when the distance between the charges increases. Analyze the data to determine patterns and trends. Formulate a conclusion about the relationship. Represent the data graphically. Recognize that the electrical force increases as the electrical charges increases. Support the conclusion with evidence from the **SIMULATION**.

Instructional Strategies and Resources

- Coulomb's Law, an interactive **SIMULATION** from the State University of New York's Department of Chemistry, allows students to change the amount and distance between two charges and see the resulting change in electric force.

CONTENT STATEMENT

Forces have magnitude and direction.

The motion of an object is always measured with respect to a reference point.
Forces can be added. The net force on an object is the sum of all of the forces acting on the object. The net force acting on an object can change the object's direction and/or speed.
When the net force is greater than zero, the object's speed and/or direction will change.
When the net force is zero, the object remains at rest or continues to move at a constant speed in a straight line.

Instructional Strategies and Resources

- *Friction*, an interactive **SIMULATION** from BBC Schools, allows students to apply different forces to start a cart moving and explore how far the cart travels on different surfaces.
- *Forces in Action*, an interactive **SIMULATION** from BBC Schools, allows students to observe how different-sized parachutes with different amounts of drag affect the motion of a truck.
- *Gravity Force Lab*, an interactive **SIMULATION** from PhET, allows students to visualize the gravitational force that two objects exert on each other. Students may change the mass of and distance between the objects and observe the changes in the gravitational force.
- *Forces in 1-Dimension* is an interactive **SIMULATION** from PhET that allows students to use different forces to push an object, see the resulting friction force, net force, and any change in motion that occurs.

CONTENT STATEMENT

There are different types of potential energy.

Gravitational potential energy changes in a system as the masses or relative positions of objects are changed. Objects can have elastic potential energy due to their compression or chemical potential energy due to the nature and arrangement of the atoms that make up the object.

Instructional Strategies and Resources

- *Masses and Springs* is an interactive **SIMULATION** from PhET that has a realistic **SIMULATION** of a mass and spring lab. Students select a mass to hang from a spring and adjust the spring stiffness and damping. The results can be observed in slow motion and the **SIMULATION** includes transporting the apparatus to different planets. A chart can show the kinetic, potential and thermal energy for each spring.