ADOPTED JULY 2011

Ohio's New Learning Standards:

# Science Standards

Ohio | Department of Education

# Table of Contents

**Ohio Revised Science Education Standards and Model Curriculum** 3

Model Curriculum Definitions 8

Table 1: Ohio's Cognitive Demands for Science 10

Table 2: Expectations for Technological and Engineering Design 11

Description of a Scientific Model 12

**Ohio Revised Science Standards and Model Curriculum Grades PreK through Eight** 13

INDEX: 13

Topics by Grade Level 14

Kindergarten 15

Grade 1 35

Grade 2 56

Grade 3 76

Grade 4 106

Grade 5 132

Grade 6 159

Grade 7 203

Grade 8 239

**Ohio Revised Science Standards and Model Curriculum High School** 275

**Introductory High School Sciences**

Physical Science 275

Biology 288

**Advanced Sciences**

Chemistry 297

Environmental Science 306

Physical Geology 316

Physics 330

BACK TO INDEX

# Ohio Revised Science Education Standards and Model Curriculum

## OVERVIEW

This overview reiterates the vision and goals of the *Ohio Revised Science Education Standards and Model Curriculum,* provides the guiding principles that framed the development of the materials, and contains the definitions used in the documents. It also contains draft definitions for the *Cognitive Demands* that have guided the development of the *Expectations for Learning* component.

## VISION

The *Ohio Revised Academic Content Standards and Model Curriculum for Science Education* serve as a basis for what all students should know and be able to do in order to become scientifically literate citizens equipped with knowledge and skills for the 21st century workforce and higher education. Ohio educators are provided with the content and expectations for learning upon which to base science curriculum at each grade level. By the end of high school, students should graduate with sufficient proficiency in science to:

- Know, use and interpret scientific explanations of the natural world;
- Generate and evaluate scientific evidence and explanations, distinguishing science from pseudoscience;
- Understand the nature and development of scientific knowledge;
- Participate productively in scientific practices and discourse.[1]

The PreK-8 and high school documents are designed to provide guidance for educators who have the responsibility to teach science to Ohio students. Each *Content Statement and Content Elaboration* presents what students should know about that science. The accompanying *Expectations for Learning* incorporate science skills and processes, and technological and engineering design. The *Visions into Practice* section offers optional examples of tasks that students may perform to learn about the science as well as demonstrate their mastery of the grade-level materials. The *Instructional Strategies and Resources* section further subdivides into sections on *Diverse Learners, Common Misconceptions and Classroom Portals*.

It is the blending of the *Content Statements and Content Elaborations* with the *Expectations for Learning* that will provide the basis for future assessments.

## GOALS

Ohio's student-centered goals (Duschl et. al., 2007; Bell et. al. 2009) for science education include helping students:

1. Experience excitement, interest and motivation to learn about phenomena in the natural and physical world.
2. Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science.
3. Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world.
4. Reflect on science as a way of knowing; on processes, concepts and institutions of science; and on their own process of learning about phenomena.
5. Participate in scientific activities and learning practices with others, using scientific language and tools.
6. Think about themselves as science learners and develop an identity as someone who knows about, uses and sometimes contributes to science.

These goals are consistent with the expectations noted in Am. Sub. House Bill 1.[2]

[1] Paraphrased from Bruce Alberts, past President of the National Academy of Science and current editor of *Science Magazine*. Retrieved from the web on April 13, 2010: http://www.whitehouse.gov/files/documents/ostp/PCAST/Alberts.pdf.

[2] ORC §3301.079 A (1): http://codes.ohio.gov/orc/3301.

BACK TO INDEX

## GUIDING PRINCIPLES

The Revised Science Education Standards have been informed by international and national studies, educational stakeholders and academic content experts. The guiding principles include:

- **Definition of Science:** Science is a systematic method of continuing investigation, based on observation, scientific hypothesis testing, measurement, experimentation and theory building, which leads to explanations of natural phenomena, processes or objects that are open to further testing and revision based on evidence.[3] Scientific knowledge is logical, predictive and testable, and grows and advances as new evidence is discovered.
- **Scientific Inquiry:** There is no science without inquiry. Scientific inquiry is a way of knowing and a process of doing science. It is the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas as well as an understanding of how scientists study the natural world.[4] Teachers need to model scientific inquiry by teaching with inquiry.
- **21st Century Skills:** 21st century skills are integral to the science standards and curriculum development revision documents. They are an essential part of the model curriculum component through the incorporation and integration of scientific inquiry, science skills and process and technological and engineering design. As enumerated by Am. Sub. H.B. 1, these skills include: creativity and innovation; critical thinking, problem solving and communication; information, media and technological literacy; personal management, productivity, accountability, leadership and responsibility; and interdisciplinary, project-based, real-world learning opportunities.[5]
- **Technological Design:** Technological design is a problem or project-based way of applying creativity, science, engineering and mathematics to meet a human need or want. Modern science is an integrated endeavor. Technological design integrates learning by using science, technology, engineering and mathematics and fosters 21st Century Skills.
- **Technology and Engineering:** Technology modifies the natural world through innovative processes, systems, structures and devices to extend human abilities. Engineering is design under constraint that develops and applies technology to satisfy human needs and wants. Technology and engineering, coupled with the knowledge and methods derived from science and mathematics, profoundly influence the quality of life.
- **Depth of Content:** It is vital that the *Content Statements and Content Elaborations* within the standards document communicate the most essential concepts and the complexity of the discipline in a manner that is manageable and accessible for teachers. The focus is on what students must know to master the specific grade-level content. The *Expectations for Learning* cognitive demands provide the means by which students can demonstrate this grade-level mastery.
- **Internationally Benchmarked:** Ohio's Revised Science Education Standards and Model Curriculum incorporate research from investigations of the science standards of:
  - Countries whose students demonstrate high-performance on both the Trends in International Mathematics and Science Studies (TIMSS) and Program in Student Assessment (PISA) tests; and
  - States with students who perform well on the National Assessment of Education Progress (NAEP).

  As a result, there is a clear focus on rigor, relevance, coherence and organization, with an emphasis on horizontal and vertical articulation of content within and across disciplines.
- **Assessment:** Ohio's assessment system will be informed by and aligned with the *Content Statements, Content Elaborations and Expectations for Learning*.
- **Standards and Curriculum:** The Standards and Model Curriculum provide a framework from which local curricula can be developed. They themselves are not the curriculum. The curriculum will continue to be a local responsibility.

[3] National Research Council (1996), *National Science Education Standards* (Washington, DC: National Academy Press) and including excerpts with minor revision, of The Ohio Academy of Science (2000) definition of science: **http://www.ohiosci.org/Whatisscience**. PDF Acc

[4] Research Council (1996), *National Science Education Standards* (Washington, DC: National Academy Press), p 192.

[5] **http://www.21stcenturyskills.org/index.php?option=com_content&task=view&id=254&Itemid=119; ORC §3301.079 A (1): http://codes.ohio.gov/orc/3301**.

BACK TO INDEX

## FORMAT AND DEVELOPMENT OF THE STANDARDS AND MODEL CURRICULUM

The Standards and Model Curriculum are a Web-based resource that provides information and support on "How" to plan, develop, implement and evaluate instruction directly aligned to standards. They include *Content Elaborations; Expectations for Learning* that will incorporate additional information on teaching strategies through the *Examples for the Classroom; Visions into Practice,* and *Instructional Strategies*, with selected resources and suggestions for *Diverse Learners, Common Misconceptions* and *Classroom Portals*. Every PreK to 8 Content Statement is accompanied by a Model Curriculum. Each high school course also is accompanied by a Model Curriculum aligned to specific topical areas. Table 1 contains the definitions for each of the terms used.

The *Content Elaborations, Expectations for Learning* and accompanying *Visions into Practice* examples were developed by ODE staff in collaboration with education stakeholders. The definitions of the four *Cognitive Demands* of the *Expectations for Learning* that guided the development of the *Visions into Practice* were compiled from research and national frameworks. Table 2 provides descriptions for each of the four *Cognitive Demands*.

The *Instructional Strategies and Resources* sections were populated with recommendations from ODE staff and recommendations from the field. During the summer of 2010, 144 meetings were held throughout the 16 State Support Team Regions. These meetings provided opportunities for teachers to contribute to the *Instructional Strategies* components. In addition, more than 60 professional and industrial organizations in science or science-related technological and engineering fields were contacted for recommendations on real-world applications relevant to the revised science education standards. Members of the Ohio Academy of Sciences and members of higher education faculty also were invited to participate.

The *Instructional Strategies and Resources* portion of the Model Curriculum is intended to be dynamic. When fully functional as a Web-based interactive system, it will be able to be updated regularly to reflect current research and to ensure that links to suggested teaching resources and materials remain active.

## TRANSITION PERIOD

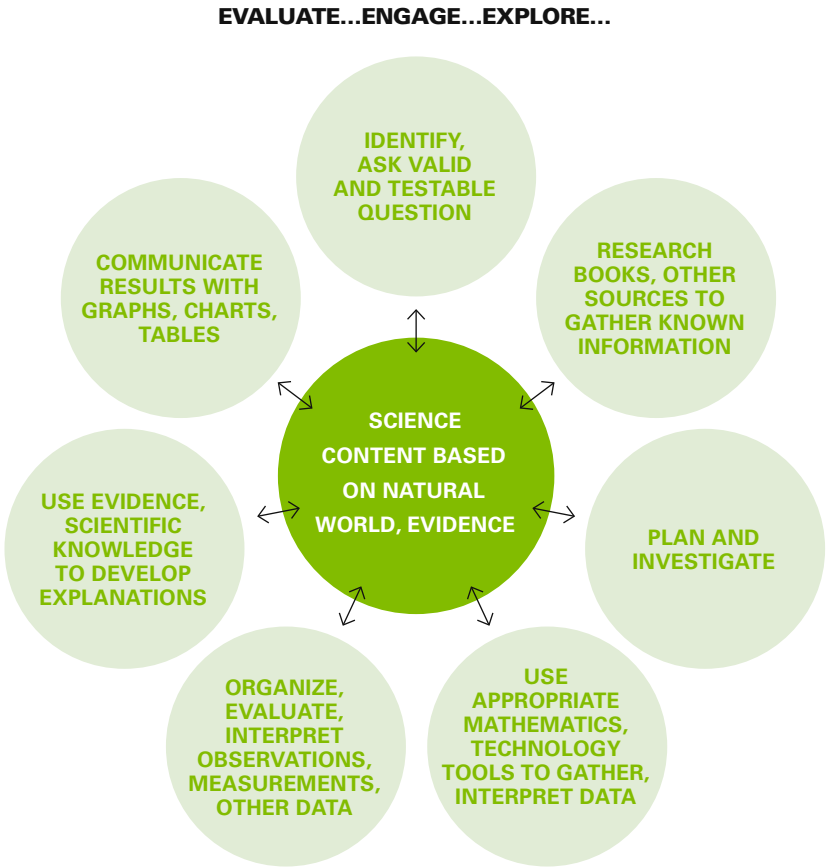
The Revised Science Education Standards and Model Curriculum will not be fully implemented until 2014 to allow time for development of aligned assessments. However, even though the new materials look different to accommodate more specificity and have a different emphasis by eliminating indicators and focusing on depth of content, scientific inquiry has been at the core of all the development.

Teachers can begin to transition to the new materials by becoming familiar with the new format and the *Expectations for Learning* framed by the *Cognitive Demands* and by continuing to implement the Scientific Inquiry/Learning Cycle that has been recommended by ODE since 2002. All components of the Model Curriculum are compatible with the 5Es of the Learning Cycle.

The process of scientific inquiry incorporates universal skills, such as collaboration, critical thinking, problem solving, communication, research and meta-cognition that are commonly thought of as 21st century process skills. Teaching by inquiry allows students to learn and demonstrate both scientific skills and technological/engineering design skills which addresses the goals of career and college readiness.

BACK TO INDEX

## SCIENTIFIC INQUIRY/LEARNING CYCLE




Teachers using the 5Es and grounded in the content of the revised science standards will be able to:

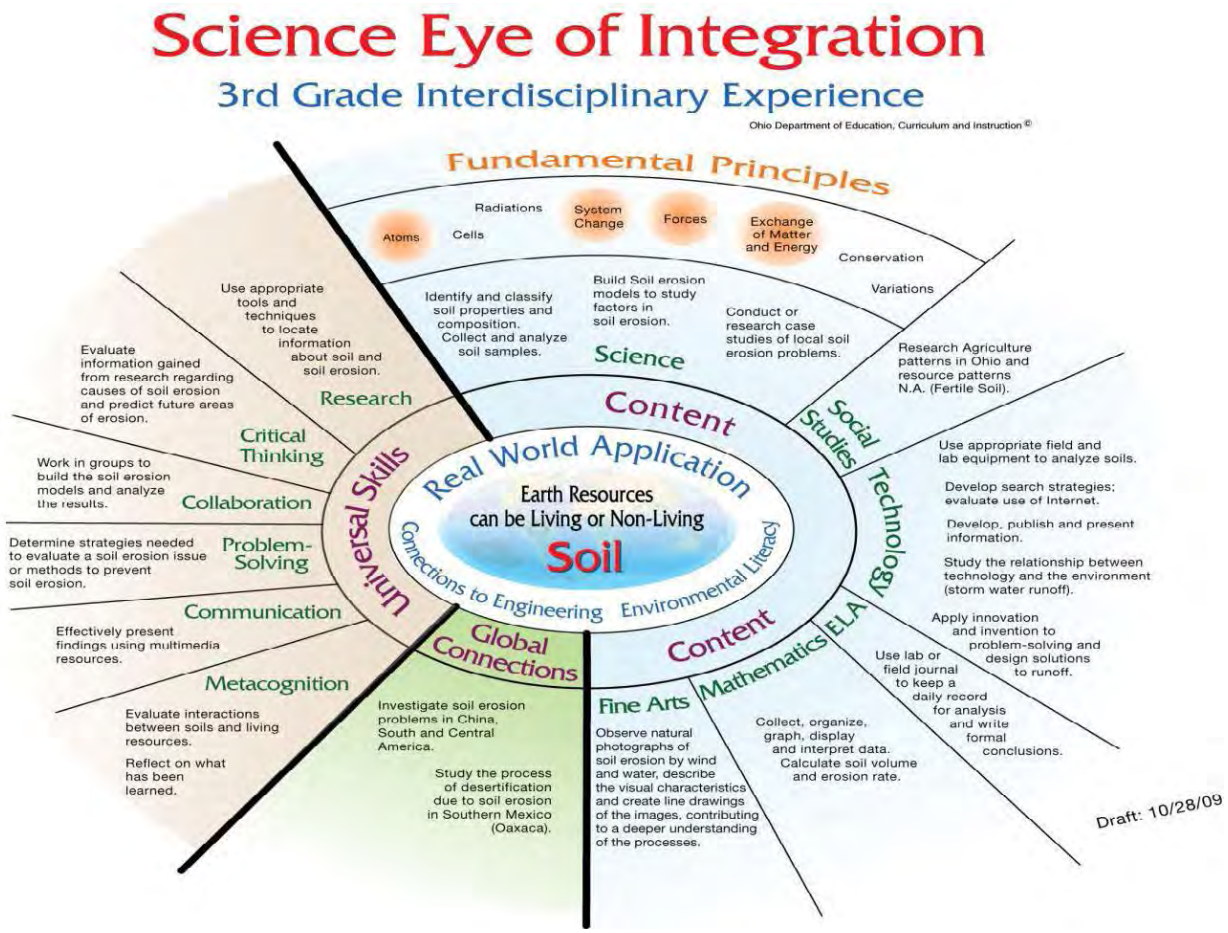
- Scaffold their students in framing questions, grappling with data, creating explanations, and critiquing explanations (including others in public forum) – all important components of inquiry.
- Select instructional materials from the Model Curriculum that promote the teaching and learning of science by inquiry.
- Assess students' abilities in multiple ways that are compatible with inquiry.

Students engaging with grade appropriate science content in depth through the Scientific Inquiry/Learning Cycle will be better prepared to meet the challenges they will be confronting as they enter higher education or pursue a career.

BACK TO INDEX

## VISION FOR THE FUTURE

The *Eye of Integration* is a vision for the future. It is a Web-based portal to be developed following Phase II, the Model Curriculum.



BACK TO INDEX

## Model Curriculum Definitions

**Strands:** These are the science disciplines: Earth and space sciences, physical sciences; life science. Overlaying all the content standards and embedded in each discipline are science inquiry and applications.

**Grade Band Themes:** These are the overarching ideas that connect the strands and the topics within the grades. Themes illustrate a progression of increasing complexity from grade to grade that is applicable to all the strands.

**Strand Connections:** These are the overarching ideas that connect the strands and topics within a grade. Connections help illustrate the integration of the content statements from the different strands.

**Topics:** The Topics are the main focus for content for each strand at that particular grade level. The Topics are the foundation for the specific content statements.

**Content Statements:** These state the science content to be learned. These are the "what" of science that should be accessible to students at each grade level to prepare them to learn about and use scientific knowledge, principles and processes with increasing complexity in subsequent grades.

**Note: The content statements and associated model curriculum may be taught in any order. The sequence provided here does not represent the ODE-recommended sequence as there is no ODE-recommended sequence.**

**Model Curriculum:** The Model Curriculum is a Web-based resource that will incorporate information on "how" the material in the Content Statement may be taught. It will include Content Elaboration, Learning Expectations, and Instructional Strategies and Resources (described below).

**Content Elaboration:** This section provides anticipated grade-level depth of content knowledge and examples of science process skills that should be integrated with the content. This section also provides information to help identify what prior knowledge students should have and toward what future knowledge the content will build.

**Expectations for Learning:** This section provides definitions for Ohio's science cognitive demands, which are intrinsically related to current understandings and research about how people learn. They provide a structure for teachers and assessment developers to reflect on plans for teaching science, to monitor observable evidence of student learning, and to develop summative assessment of student learning of science. Ohio's cognitive demands for science include designing technological and engineering solutions using scientific concepts, demonstrating scientific knowledge, interpreting and communicating scientific concepts and recalling accurate science.

**Vision into Practice:** This section provides optional examples of tasks that students may perform, these task are not mandated. It includes designing technological and engineering solutions using scientific concepts, demonstrating scientific knowledge, interpreting and communicating scientific concepts and recalling accurate science. This provides guidance for developing classroom performance tasks and assessments. These are examples not an all-inclusive checklist of what should be done, but a springboard for generating innovative ideas.

BACK TO INDEX

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

Subcategories of Instructional Strategies and Resources include:

- **Common Misconceptions:** This section identifies misconceptions that students often have about the particular Content Statement. When available, links to resources are provided that describe the misconception and that offer suggestions for helping students overcome them.
- **Diverse Learners:** This section will include ideas about different ways of approaching a topic to take into consideration diverse learning styles. It will contain a variety of instructional methods designed to engage all students to help them gain deep understanding of content through scientific inquiry, technology and technological and engineering design.
- **Classroom Portals:** This section provides windows into the classroom through webcasts, podcasts and video clips to exemplify and model classroom methods of teaching science using inquiry and technological design.

BACK TO INDEX

**Resources**: Frameworks that were consulted in the development of the draft cognitive demands are listed below. Each links to a brief description of the framework.

**NAEP:** *Science Framework for the 2009 National Assessment of Educational Progress* (2008), **http://www.nagb.org/publications/frameworks/science-09.pdf.**

**Revised Bloom's Taxonomy:** See Anderson, et.al. *A Taxonomy for Learning, Teaching and Assessing* (2001), **http://projects.coe.uga.edu/epltt/index.php?title=Bloom%27s_Taxonomy.**

**TIMSS:** *TIMSS 2007 Assessment Frameworks* (2005), **http://timss.bc.edu/TIMSS2007/PDF/T07_AF_chapter2.pdf.**

**Survey of Enacted Curriculum:** *Coding Procedures for Curriculum Content Analyses* (2004), **http://seconline.wceruw.org/Reference/K12Taxonomy08.pdf.**

**PISA:** *The PISA 2003 Assessment Domains* (2003), **http://www.oecd.org/dataoecd/46/14/33694881.pdf.**

**Ohio's Technology Standards:** Ohio Academic Content Standards in Technology (2003), **http://www.ode.state.oh.us/GD/Templates/Pages/ODE/ODEPrimary.aspx?Page=2&TopicID=1696&TopicRelationID=1707**.

# Table 1: Ohio's Cognitive Demands for Science

## OHIO REVISED SCIENCE STANDARDS MODEL CURRICULUM: EXPECTATIONS FOR LEARNING COGNITIVE DEMANDS

As with all other frameworks and cognitive demand systems, Ohio's revised system has overlap between the categories. *Recalling Accurate Science* is a part of the other three cognitive demands included in Ohio's framework, because science knowledge is required for students to demonstrate scientific literacy.

| COGNITIVE DEMAND | DESCRIPTION |
|---|---|
| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS (T) | Requires student to solve science-based engineering or technological problems through application of scientific inquiry. Within given scientific constraints, propose or critique solutions, analyze and interpret technological and engineering problems, use science principles to anticipate effects of technological or engineering design, find solutions using science and engineering or technology, consider consequences and alternatives, and/or integrate and synthesize scientific information. |
| DEMONSTRATING SCIENCE KNOWLEDGE (D) | Requires student to use **scientific inquiry** and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather and organize data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments. (Slightly altered from National Science Education Standards)<br><br>**Note: Procedural knowledge (knowing how) is included in *Recalling Accurate Science*.** |
| INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS (C) | Requires student to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge.<br><br>Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information. |
| RECALLING ACCURATE SCIENCE (R) | Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles. |

BACK TO INDEX

[1] *Ohio Academic Content Standards for Technology*, December 2003 (Ohio Department of Education). *Technology for All Americans: A Rationale and Structure for All Americans Project*, 1996 (International Technology Association, Reston, VA).

# Table 2: Expectations for Technological and Engineering Design

## OHIO REVISED SCIENCE STANDARDS MODEL CURRICULUM

Below are examples of the grade-appropriate skills expected of students as they become engaged in the cognitive domain of *Designing Technological/Engineering Solutions Using Science Concepts*.[1] These skills complement those of scientific inquiry that are expected to be achieved by the end of the selected grade bands in PreK-8 and at the end of high school.

| TECHNOLOGICAL AND ENGINEERING DESIGN | |
|---|---|
| **PREK-4** | **GRADES 5-8** |
| Identify problems and potential technological/engineering solutions | Understand and be able to select and use physical and informational technologies |
| Understand the design process, role of troubleshooting | Understand how all technologies have changed over time |
| Understand goals of physical, informational and bio-related technologies | Recognize role of design and testing in the design process |
| Understand how physical technologies impact humans | Apply research, innovation and invention to problem solving |

| TECHNOLOGICAL AND ENGINEERING DESIGN GRADES 9-12 |
|---|
| Demonstrate an understanding of the relationship among people, technology, engineering and the environment |
| Identify a problem or need, consider design criteria and constraints |
| Integrate multiple disciplines when problem solving |
| Synthesize technological and engineering knowledge and design in problem solving |
| Apply research, development, experimentation and redesign based on feedback to problem solving |
| Build, test and evaluate a model or prototype that solves a problem or a need |

BACK TO INDEX

## Description of a Scientific Model

A scientific model is a mental construct that represents a large-scale system or process. The model may be abstract, conceptual, mathematical, graphical and/or computer-based. Scientific models are valuable to promote understanding of interactions within and between systems and to explain and predict observed phenomena as simply as possible. It is important to note that scientific models are incomplete representations of the actual systems and phenomena. They can change over time as new evidence is discovered that cannot be explained using the old model. Since the goal of a model is to promote understanding, simpler, less complete models can still be used when more advanced and complex models do little to contribute to the understanding of the phenomenon considered. For example, the quantum model of the atom would not necessarily be the best model to use to understand the behavior of gases.

BACK TO INDEX

# Ohio Revised Science Standards and Model Curriculum Grades PreK through Eight

## INDEX:

**TOPICS BY GRADE LEVEL**

**KINDERGARTEN**
Earth, Life, Physical

**GRADE 1**
Earth, Life, Physical

**GRADE 2**
Earth, Life, Physical

**GRADE 3**
Earth, Life, Physical

**GRADE 4**
Earth, Life, Physical

**GRADE 5**
Earth, Life, Physical

**GRADE 6**
Earth, Life, Physical

**GRADE 7**
Earth, Life, Physical

**GRADE 8**
Earth, Life, Physical

## LEGEND

**ENVIRONMENTAL LITERACY**

**TECHNOLOGY LITERACY**

**21ST CENTURY SKILLS**

**EYE OF INTEGRATION EXAMPLE**

BACK TO INDEX

BACK TO K-8 INDEX

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

# Topics by Grade Level

| THEMES | | THE PHYSICAL SETTING | | THE LIVING ENVIRONMENT | SCIENCE INQUIRY AND APPLICATIONS |
|---|---|---|---|---|---|
| | | EARTH AND SPACE SCIENCE | PHYSICAL SCIENCE | LIFE SCIENCE | |
| **Observations of the Environment**<br>This theme focuses on helping students develop the skills for systematic discovery to understand the science of the natural world around them in greater depth by using scientific inquiry. | K | *Living and nonliving things have specific physical properties that can be used to sort and classify. The physical properties of air and water are presented as they apply to weather.* | | | During the years of PreK to grade 4, all students must develop the ability to:<br>• Observe and ask questions about the natural environment;<br>• Plan and conduct simple investigations;<br>• Employ simple equipment and tools to gather data and extend the senses;<br>• Use appropriate mathematics with data to construct reasonable explanations;<br>• Communicate about observations, investigations and explanations; and<br>• Review and ask questions about the observations and explanations of others. |
| | | Daily and Seasonal Changes | Properties of Everyday Objects and Materials | Physical and Behavioral Traits of Living Things | |
| | 1 | *Energy is observed through movement, heating, cooling and the needs of living organisms.* | | | |
| | | Sun, Energy and Weather | Motion and Materials | Basic Needs of Living Things | |
| | 2 | *Living and nonliving things may move. A moving object has energy. Air moving is wind and wind can make a windmill turn. Changes in energy and movement can cause change to organisms and the environment in which they live.* | | | |
| | | The Atmosphere | Changes in Motion | Interactions within Habitats | |
| **Interconnections within Systems**<br>This theme focuses on helping students explore the components of various systems and then investigate dynamic and sustainable relationships within systems using scientific inquiry. | 3 | *Matter is what makes up all substances on Earth. Matter has specific properties and exists in different states Earth's resources are made of matter, can be used by living things and can be used for the energy they contain. There are many different forms of energy. Each living component of an ecosystem is composed of matter and uses energy.* | | | |
| | | Earth's Resources | Matter and Forms of Energy | Behavior, Growth and Changes | |
| | 4 | *Heat and electrical energy are forms of energy that can be transferred from one location to another. Matter has properties that allow the transfer of heat and electrical energy. Heating and cooling affect the weathering of Earth's surface and Earth's past environments. The processes that shape Earth's surface and the fossil evidence found can help decode Earth's history.* | | | |
| | | Earth's Surface | Electricity, Heat and Matter | Earth's Living History | |
| | 5 | *Cycles on Earth, such as those occurring in ecosystems, in the solar system and in the movement of light and sound, result in describable patterns. Speed is a measurement of movement. Change in speed is related to force and mass*. The transfer of energy drives changes in systems, including ecosystems and physical systems.* | | | During the years of grades 5 through 8, all students must have developed the ability to:<br>• Identify questions that can be answered through scientific investigations;<br>• Design and conduct a scientific investigation;<br>• Use appropriate mathematics, tools and techniques to gather data and information;<br>• Analyze and interpret data;<br>• Develop descriptions, models, explanations and predictions;<br>• Think critically and logically to connect evidence and explanations;<br>• Recognize and analyze alternative explanations and predictions; and<br>• Communicate scientific procedures and explanations. |
| | | Cycles and Patterns in the Solar System | Light, Sound and Motion | Interactions within Ecosystems | |
| **Order and Organization**<br>This theme focuses on helping students use scientific inquiry to discover patterns, trends, structures and relationships that may be inferred from simple principles. These principles are related to the properties or interactions within and between systems. | 6 | *All matter is made of small particles called atoms. The properties of matter are based on the order and organization of atoms and molecules. Cells, minerals, rocks and soil are all examples of matter.* | | | |
| | | Rocks, Minerals and Soil | Matter and Motion | Cellular to Multicellular | |
| | 7 | *Systems can exchange energy and/or matter when interactions occur within systems and between systems. Systems cycle matter and energy in observable and predictable patterns.* | | | |
| | | Cycles and Patterns of Earth and the Moon | Conservation of Mass and Energy | Cycles of Matter and Flow of Energy | |
| | 8 | *Systems can be described and understood by analysis of the interaction of their components. Energy, forces and motion combine to change the physical features of the Earth. The changes of the physical Earth and the species that have lived on Earth are found in the rock record. For species to continue, reproduction must be successful.* | | | |
| | | Physical Earth | Forces and Motion | Species and Reproduction | |

BACK TO INDEX
BACK TO K-8 INDEX

# Kindergarten

## INTRODUCTION TO CONTENT STATEMENTS

### GRADE BAND THEME: OBSERVATIONS OF THE ENVIRONMENT

This theme focuses on helping students develop the skills for systematic discovery to understand the science of the physical world around them in greater depth by using scientific inquiry.

#### SCIENCE INQUIRY AND APPLICATION

During the years of PreK-4, all students must become proficient in the use of the following scientific processes, with appropriate **laboratory safety techniques**, to construct their knowledge and understanding in all science content areas:

- Observe and ask questions about the natural environment;
- Plan and conduct **simple investigations**;
- Employ simple equipment and tools to gather data and extend the senses;
- Use appropriate mathematics with data to construct reasonable explanations;
- Communicate about observations, investigations and explanations; and
- Review and ask questions about the observations and explanations of others.

#### STRANDS

**Strand Connections:** Living and nonliving things have specific physical properties that can be used to sort and classify. The physical properties of air and water are presented as they apply to weather.

| EARTH AND SPACE SCIENCE (ESS) | PHYSICAL SCIENCE (PS) | LIFE SCIENCE (LS) |
|---|---|---|
| Topic: **Daily and Seasonal Changes**<br>This topic focuses on observing, exploring, describing and comparing weather changes, patterns in the sky and changing seasons. | Topic: **Properties of Everyday Objects and Materials**<br>This topic focuses on the production of sound and on observing, exploring, describing and comparing the properties of objects and materials with which the student is familiar. | Topic: **Physical and Behavioral Traits of Living Things**<br>This topic focuses on observing, exploring, describing and comparing living things in Ohio. |
| **CONDENSED CONTENT STATEMENTS** | | |
| • Weather changes are long-term and short-term.<br>• The moon, sun and stars are visible at different times of the day or night. | • Objects and materials can be sorted and described by their properties.<br>• Some objects and materials can be made to vibrate to produce sound. | • Living things are different from nonliving things.<br>• Living things have physical traits and behaviors, which influence their survival. |

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM KINDERGARTEN

# EARTH AND SPACE SCIENCE (ESS)

**Topic: Daily and Seasonal Changes**

This topic focuses on observing, exploring, describing and comparing weather changes, patterns in the sky and changing seasons.

### 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.

**Note: The focus is on observing the weather patterns of seasons. The reason for changing seasons is not appropriate for this grade level; this is found in grade 5.**

### CONTENT ELABORATION

**Kindergarten Concepts**

Wind, temperature and precipitation are components of the weather that can be observed and measured for Kindergarten. The measurements collected and tools used can be nonstandard and must be age-appropriate. For example, the temperature may be above or below a given point (warmer or colder) or the amount of snow is marked on a dowel rod to check the depth.

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.

**Future Application of Concepts**

**Grades 1-2:** The properties of water and air are explored as they relate to the weather observations and measurement from Kindergarten.

**Grades 3-5:** Different states of water are defined in Physical Sciences. Wind and water are recognized as processes that can change the surface of Earth through weathering and erosion. The observed seasons from Kindergarten are related to the sun and the tilt and orbit of Earth in grade 5.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| As a class, make a portable weather station that can measure wind, temperature and precipitation amounts.<br><br>Test and select the best location for the weather station (so that accurate readings can be collected). | Experiment with different methods or make/use tools to collect precipitation amounts (rain, snow or ice) and measure the speed (faster or slower) and direction of wind (*which way is the wind blowing?*). Ask questions about what happens next, such as: *When the wind increases, what happens to the temperature?*<br><br>**Note: Nonstandard measurements can be used to meet this objective.** | Make a weather chart or graphic that documents observed weather on a regular basis throughout the year. As a class, compare changes in temperature, precipitation and wind and include the changes that are observed each day, each week and month to month. | Identify the four different seasons. Recognize that temperature, wind and precipitation are different ways to measure weather. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Children need to be encouraged to experiment with ways to measure weather and how to measure weather accurately. Asking effective questions as children are trying different methods is an important part of understanding what the child knows pertaining to measuring weather. Allow children to make their own tools to measure weather using everyday materials. **Weather tools**, such as windmills, windsocks or rain gauges, can be very creative and artistic products that can actually measure the weather.

### Career Connection

Students will maintain a class weather chart where they will record each day's weather. As a class, students will discuss types of jobs that are related to weather or seasons (e.g., meteorologist, landscaper, construction worker, truck driver). Discuss examples such as, *Which jobs are done outdoors? Which jobs are done in the summer? Which jobs are done in the winter?*

## COMMON MISCONCEPTIONS

- Misconceptions about weather and weather observations at this age often stem from children's literature and expressions (Old Man winter, raining cats and dogs, raining buckets, fog like pea soup). Reading stories that include accurate representation of weather events can be a good start to addressing misconceptions. Collecting and discussing weather data on a regular basis will help to clarify weather at this age. For examples of age-appropriate, scientifically accurate storybooks about rain and wind, visit **http://www.magnet.fsu.edu/education/community/scienceinliterature/picturebooks.html**.
- NASA lists common misconceptions for all ages about the sun and the Earth, including weather and seasons, at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies *Jennie–K* and *Elsa–K* are examples of how to design age-appropriate science investigations using activities and games to interest students in science.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM KINDERGARTEN

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Daily and Seasonal Changes**

This topic focuses on observing, exploring, describing and comparing weather changes, patterns in the sky and changing seasons.

### CONTENT STATEMENT

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

The moon, sun and stars are in different positions at different times of the day or night. Sometimes the moon is visible during the night, sometimes the moon is visible during the day and at other times, the moon is not visible at all. The observable shape of the moon changes in size very slowly throughout each day of every month. The sun is visible only during the day.

The sun's position in the sky changes in a single day and from season to season. Stars are visible at night, some are visible in the evening or morning and some are brighter than others.

### CONTENT ELABORATION

**Kindergarten Concepts**

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.

**Future Application of Concepts**

**Grades 1-2:** The sun is introduced as a primary source of energy that relates to long- and short-term weather changes.

**Grades 3-5:** The tilt and orbit of the Earth and position of the sun are related to the seasons, the sun is the only star in the solar system and celestial bodies orbit the sun.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| As a class, design and make a sun garden. The garden may contain rocks or other objects that reflect or react to sunlight, such as sundials, solar powered lights or chimes that require sunlight for movement.<br><br>Placement of the garden must be based upon the sun-shadow data (see Demonstrating Science Knowledge). The design should be drawn on a map and discussed with the class. | 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?***<br><br>Use light bulbs, overhead projectors, virtual investigations or combinations of the above to explore inside shadows. | Collect and record sun-shadow data on a regular basis throughout the school day and school year. Interpret the changes (length, position) in the shadows. Discuss the changes that are observed, the relationship between the changes in the shadows, and the different positions of the sun during the day and in the different seasons. Present findings orally and/or graphically. | Recognize that the sun changes position in the sky during the day. |
| | | Make a table or chart to document the changes in the observable (lit) part of the moon throughout a month. Compare the differences throughout the month and then determine if the same pattern exists the next month. | Recall that the moon is visible at night and sometimes during the day. The visible part of the moon changes throughout the month. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Observing the sun, moon and shadows, both inside and outside and then asking effective questions about the observations can help plan further investigation. Asking questions about *what happens when ... or what happens if ...* can encourage children to predict, experiment and **explore** with shadows or observed changes in the sun or moon.
- There are many different ways to explore how shadows are forms and what effects changes in the size of shadows. At this age, it is important to allow children to test out their own ideas and explain what they are doing as they experiment. **Effective questioning** and student-led investigation can support the use of inquiry and the understanding of factors that are needed to change the size and shape of shadows.
- Introduce the element of prediction by encouraging children to ask and answer questions about what happens if… Provide time and materials for experimental trial and error, and exploration. Experiments and investigations should take place inside and outside of the classroom.
- **NSTA** offers a number of science modules (SciPacks) for teachers. This SciPack inquiry module addresses teaching about the sun and energy at an early-childhood level.

## COMMON MISCONCEPTIONS

- AAAS offers a narrative section on The Universe that explains the importance of introducing the sun, moon and stars through observation and discusses common misconceptions of K-2 students at **http://www.project2061.org/publications/bsl/online/index.php?chapter=4#A1**.
- Beyond Penguins and Polar Bears is an online magazine for K-5 teachers. It lists a number of misconceptions held by students regarding the sun and seasons, including that the sun is actually moving across the sky, rather than understanding it is the Earth that is moving. For more information, visit **http://beyondpenguins.nsdl.org/issue/column.php?date=May2008&departmentid=professional&columnid=professional!misconceptions**.
- NASA lists common misconceptions for all ages about the sun and the Earth at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies *Jennie–K* and *Elsa–K* are examples of how to design age-appropriate science investigations that use activities and games to interest students in science.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE KINDERGARTEN

## LIFE SCIENCE (LS)

**Topic: Physical and Behavioral Traits of Living Things**

This topic focuses on observing, exploring, describing and comparing living things in Ohio.

### CONTENT STATEMENT

**Living things are different from nonliving things.**

Living things include anything that is alive or has ever been alive. Living things have specific characteristics and traits. Living things grow and reproduce. Living things are found almost everywhere in the world. There are somewhat different kinds in different places.

**Note 1: The focus is on the traits and behaviors of living things not on attributes of nonliving things. See Kindergarten Physical Science for nonliving things.**

**Note 2: Listing the characteristics that distinguish living things from nonliving things is not appropriate at this grade level. Further details will appear in the model curriculum.**

### CONTENT ELABORATION

**Kindergarten Concepts**

The emphasis of this content statement is to build a grade-appropriate understanding of what it means to be living, not to distinguish living and nonliving.

There are different kinds of living things. The focus is on familiar organisms (e.g., grass, trees, flowers, cats, dogs, horses). Some grade-appropriate characteristics include that living things respond to stimuli, grow and require energy.

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.

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.

**Future Application of Concepts**

**Grades 1-2:** This content builds to understanding that living things use the environment to acquire what they need in order to survive.

**Grades 3-5:** Food webs and food chains are used to illustrate energy transfer within an ecosystem.

**Grades 6-8:** The characteristics of life are detailed via Modern Cell Theory and reproduction.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design an environment that will support a classroom pet. Provide for all of its needs including but not limited to food, water, air, shelter, cleanliness and safety. | Ask: ***Which type of flower attracts more birds, butterflies, bees or moths?*** Investigate by growing a flower garden and keeping accurate records of which types of animals visit each chosen type of flower. | Explain a way to determine if something is alive (e.g., ***are plants alive?***) | Provide an example of how plants and animals interact with one another for food, shelter and nesting. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Observe a variety of living things in the wild or the classroom and ask questions about what makes them living. ***How do they get food? Where do they live? How do they take care of their young?*** If using classroom pets, **NSTA** has a position paper to provide guidance in the ethical use and treatment of animals in the classroom.
- 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.
- ODNR-Division of Wildlife's **A to Z Species Guide** has photos, information, tracks and sounds of Ohio's wild animals
- ***Project Wild*** was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In the activity ***Surprise Terrarium***, students use a classroom terrarium to observe animal behavior and interactions.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- ***Benchmarks for Science Literacy*** contains a detailed discussion of energy. Scroll to section heading E for detailed information of grade-appropriate exposure to energy.
- **AAAS' Benchmarks 2061 Online, Chapter 15**, 5a, *Diversity of Life*, states that children use criteria such as movement, breath, reproduction and death to determine whether things are alive, which leads some to think that fire, clouds and the sun are alive. Some plants and animals are considered nonliving due to interpretation of the given criteria.

## DIVERSE LEARNERS

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

- Perkins School for the Blind, Watertown, MA, offers webcast videos including the video chapter Accessible Science – Life Science, which encourages the use of terrariums with visually handicapped students instead of aquariums.
  Find it at **http://support.perkins.org/site/PageServer?pagename=Webcasts_Acessible_Science_Life_Science**.
- Many *Project Wild* activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. In *Surprise Terrarium* students use a classroom terrarium to observe animal behavior and interactions. Information about upcoming *Project Wild* workshops is available on the **ODNR Website**.

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study *Jeanie–K* is an example of how to teach young children about observations of the living environment.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM KINDERGARTEN

## LIFE SCIENCE (LS)

**Topic: Physical and Behavioral Traits of Living Things**

This topic focuses on observing, exploring, describing and comparing living things in Ohio.

### 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.

**Note: This concept is addressed in PreK, but is included here for districts that do not have a PreK program. Further information for districts is provided in the model curriculum section.**

### CONTENT ELABORATION

**Kindergarten Concepts**

At this grade level, providing exposure through personal observation and stories to a large variety of living things is required. The focus is not on naming the parts of living things, but associating through interaction and observation that living things are made of parts, and because of those parts, living things can do specific things. The scientific explanations of how those parts function will come later. Identify and discuss examples such as birds have wings for flying and beaks for eating. Dogs have eyes for seeing, teeth for chewing and legs for moving. Trees have leaves and trunks.

Concrete experiences are necessary to deepen knowledge of the traits and behaviors of living things. Technology can be used to compare data on the number of honeybees observed in the schoolyard with other schools. Additional inquiry investigations include conducting observations of pond water (e.g., using a hand lens, focusing on macroscopic organisms), raising a classroom pet, planting seeds and watching them grow, and noting differences between different types of plants or bird watching.

**Note: To ensure the health of students, check for allergies prior to raising a classroom pet.**

**Future Application of Concepts**

**Grades 1-2:** The physical environment is identified as the source for what organisms need to survive.

**Grades 3-5:** Plants and animals have certain physical or behavioral characteristics that improve their chances of surviving in particular environments.

**Grades 6-8:** Changes in environmental conditions can affect how beneficial a trait will be for survival and reproductive success of an individual or an entire species.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design an environment that will support a classroom pet. Provide for all of its needs including but not limited to food, water, air, shelter, cleanliness and safety. | Plan an investigation to count the number of an insect pollinator that visits one type of plant (e.g., count the number of bees that visit bee balm flowers).<br>**Caution:** To ensure safety, check for student allergies to pollen and insects. | Compare a variety of living things (e.g., birds, mammals, insects, arachnids, grasses, trees) that are similar but not the same species and make a list of differences and similarities. | Identify the function of specific parts of plants and animals (e.g., plant leaves are where food is made, plant roots take in water, animal teeth are for chewing, flowers are for reproduction, ears are for hearing).<br>**Note: Assessments of this content statement will not include human biology.** |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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?* **A Guide to Using Animals in the Classroom** by the Ohio Department of Natural Resources provides guidance, explains legally which organisms may be collected and offers limited advice on use of animals in the classroom.
- **NSTA** has a position paper to provide guidance in the ethical use and treatment of animals in the classroom. These guidelines can be used for classroom pets and for helping children establish respect and proper care for animals.
- ODNR-Division of Wildlife's **A to Z Species Guide** has photos, information, tracks and sounds of Ohio's wild animals
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In the activity *Surprise Terrarium*, students use a classroom terrarium to observe animal behavior and interactions.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

Young children may give plants human characteristics such as eating, drinking or breathing. They may believe that plants need things that are provided by people. **Beyond Penguins and Polar Bears** is an online magazine for K-5 teachers that provides information for misconceptions about plants.

The Annenberg Media series **Essential Science for Teachers** can be used to provide greater insight to misconceptions children hold about living things and energy. Classroom videos and lessons are provided to help students avoid misconceptions.

## DIVERSE LEARNERS

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

- The *Project Wild* activity *Surprise Terrarium* features Universal Design for Learning principals by incorporating hands on activities for kinesthetic learners. Students use a classroom terrarium to observe animal behavior and interactions. Information about upcoming *Project Wild* workshops is available on the **ODNR Website**.

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study *Jeanie–K* is an example of how to teach young children about observations of the living environment.

BACK TO INDEX
BACK TO K-8 INDEX

## MODEL CURRICULUM KINDERGARTEN

## PHYSICAL SCIENCE (PS)

**Topic: Properties of Everyday Objects and Materials**

This topic focuses on the production of sound and on observing, exploring, describing and comparing the properties of objects and materials with which the student is familiar.

### 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.

### CONTENT ELABORATION

**Kindergarten Concepts**

In Kindergarten, the concept that objects are made of specific materials (e.g., clay, cloth, paper, metal, glass) is reinforced. Objects have certain properties (e.g., color, shape, size, temperature, odor, texture, flexibility) that can be described, compared and sorted. Temperature observations must be limited to descriptors such as hot, warm and cold. Observations of weight must be limited to describing objects as heavy or light. Comparisons must be used to sort and describe objects (e.g., ***is the wooden block heavier or lighter than the plastic block?***). Standard and nonstandard measuring tools can give additional information about the environment and can be used to make comparisons of objects and events. Magnifiers can be used to see detail that cannot be seen with the unaided eye. Familiar objects from home, the classroom or the natural environment must be explored and investigated.

**Note: Using the sense of taste should be prohibited in the classroom. Discussions of taste can be limited to experiences outside the classroom. Comparisons of objects are a precursor to measurement.**

**Future Application of Concepts**

**Grades 1-2:** Changes in objects are investigated, including temperature changes, solid-liquid phase changes and possible changes in amount of liquid water in open and/or closed containers.

**Grades 3-5:** Matter is defined and gases (air) are introduced. Measurements of weight and liquid volume are made. The mass* and kind of material remains the same when an object is reshaped or broken into pieces. The properties of solids, liquids and gases (air), and phase changes are explored.

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate objects and materials for identification, classification and understanding function.** | | | |
| Evaluate the design of an object and attribute its construction to its function (e.g., the wheel and axel for a toy car allows it to move; the separate and bendable straw makes a broom able to sweep; narrow tubing for drinking straws enables liquid to flow). Discuss findings. | Use simple tools to extend the system created for classification (e.g., classification based on length or weight, details observed with magnification or through a telescope). | Create a visual representation of a categorization of various objects and present findings orally. | Use observable (touch, see, hear, smell) information to categorize items by creating a system of organization (e.g., objects can be identified by color, shape, texture, smell). |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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. The subsequent quiz is not aligned with the content statement.

## COMMON MISCONCEPTIONS

- **Measurement** is only linear.
- Any quantity can be measured as accurately as you want.
- The five senses are infallible. Children are dependent on observable information. If the information cannot be observed with the senses, students do not believe it exists (Kind, 2004).

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

Select Video 5, Elsa–K, from this series of videos on demand produced by Annenberg. Starting at a time of about 8:50, children study **magnetic properties of matter** by sorting objects into two categories: things that can be picked up by magnets and things that cannot. While content shown in other segments of the video does not apply to this content statement, watching the entire sequence demonstrates how Elsa, a Kindergarten teacher, learns to deal with her bilingual classroom by integrating appropriate scientific experiences with lessons that also teach social, motor and communication skills. These instructional skills can be applied to any content statement.

*Essential Science for Teachers: Physical Science* is a series of videos on demand produced by Annenberg to help elementary teachers teach difficult concepts to children. Session 1, *Properties and Classification of Matter*, from a time of about 19:25 to 27:30, shows a classroom segment where children **sort materials by their properties**.

The beginning of this video on demand, produced by Annenberg, shows Jennie, a Kindergarten teacher, lead children to make observations about leaves and **form a visual representation from their observations**. While content shown in other segments of the video does not apply to this content statement, watching the entire sequence demonstrates how Jennie wants to design grade-level-appropriate science activities. The instructional strategies demonstrated can be applied to any content statement.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM KINDERGARTEN

## PHYSICAL SCIENCE (PS)

**Topic: Properties of Everyday Objects and Materials**

This topic focuses on the production of sound and on observing, exploring, describing and comparing the properties of objects and materials with which the student is familiar.

### 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.

### CONTENT ELABORATION

**Kindergarten Concepts**

Sound can be made in many ways. Objects like cymbals, the tabletop or drums can be tapped to produce sound. Objects like a rubber band or a guitar string can be plucked to produce sound. Objects like a bottle or a trumpet can be blown into to produce sound. A wide variety of sounds can be made with the same object (e.g., a plastic bottle could be tapped or blown into). The connection between sound energy and the vibration of an object must be made. Vibrations can be made visible when water splashes from a cymbal or triangle placed in water or rice vibrates on the top of a banging drum. The concepts of pitch (low vs. high notes) and loudness are introduced. The pitch of sound can be changed by changing how fast an object vibrates. Objects that vibrate slowly produce low pitches; objects that vibrate quickly produce high pitches. Sound must be experienced, investigated and explored through observations and experimentation. Standard, virtual and student-constructed instruments must be used to explore sound.

**Note: Wave descriptions of sound and the propagation of sound energy are not appropriate at this grade.**

**Future Application of Concepts**

**Grades 1-2:** Exploring sound provides an experiential basis for the concepts of motion and energy. A variety of motions is explored. Forces are needed to change the motion of objects.

**Grades 3-5:** Energy is introduced as something that can make things move or cause change. The concept of a medium for sound is introduced and disturbances in liquid and solid media are observed.

**Grades 6-8:** The wave nature of sound is introduced.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate sounds made with homemade instruments.** | | | |
| Design and make an instrument that can make different sounds by tapping, plucking or blowing.<br>Give suggestions to other students about how their instruments may make different types of sounds. | Experiment to determine how many different ways sounds can be made from an object (e.g., horn, cymbals, rubber band, guitar, plastic bottle). | Compare different ways to make loud and soft sounds by tapping, blowing or plucking objects. | Identify three ways to make sounds from objects. |
| **Investigate how the stretch of plucked rubber bands affects the sound.** | | | |
| | Use questions to investigate and experiment pitch. Ask: *How are pitch (higher/lower notes) and vibration changed as a rubber band is stretched further and further?* | Use graphics (e.g., digital photographs, virtually composed graphics) to represent the observations from the experiment.<br>Compare the notes made from rubber bands that are stretched different amounts.<br>Compare the relative speed of vibration (faster/slower) to the pitch (higher/lower notes) of the sound produced. | Recall that objects that vibrate quickly produce high notes and objects that vibrate slowly produce low notes. |

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| | **Investigate how the properties of a drum affect the sound.** | | |
| | Experiment and investigate with vibrations and sound. Ask: *How does changing a property of a homemade drum (e.g., width, depth, stretch of material) affect the vibration and the sound of the drum?*<br><br>**Note: The vibrations can be made visible by placing rice on the head of the drum.** | Use graphics (e.g., digital photographs, virtually composed graphics) to represent the observations from the experiment.<br><br>Compare the sounds made from drums with different properties. | Recognize that sound is caused by vibrating objects.<br><br>Recall that objects that vibrate quickly produce high notes and objects that vibrate slowly produce low notes. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- *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.
- Children should be given the opportunity to feel the vibrations.

## COMMON MISCONCEPTIONS

The **Operation Physics elementary/middle school outreach project** provides many misconceptions about sound. Children often think that:

- Sounds can be produced without using any material objects.
- Hitting an object harder changes the pitch of the sound produced.
- Human voice sounds are produced by a large number of vocal cords that all produce different sounds.
- Loudness and pitch of sounds are the same things.
- In wind instruments, the instrument itself vibrates (not the internal air column).
- Music is strictly an art form; it has nothing to do with science.

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

*Case Studies in Science Education* is a series of videos on demand produced by Annenberg that show teachers working on various reform issues in the classroom. In this segment, *Ingrid–Grade 1*, from a time of about 9:00, **children explore sound through class demonstrations and activities**. Children use rubber bands and geoboards to explore the relationship between pitch, speed and length. At the end of the activity, only about half of the children had observations directly pertaining to the objectives. To make sure all children were meeting the objectives, Ingrid compiled common observations that directly pertained to her objectives and shared them with the class. She had children choose one of three ideas to test. As children are doing their tests, Ingrid is circulating and asking children about their conclusions and asking them to show her the tests that support their conclusions. The children then build different instruments and make predictions about the sounds. They are challenged to build a set of drums to give different pitches. While content shown at the beginning of the video does not apply to this content statement, watching the entire sequence demonstrates how Ingrid learns to deal with incorrect ideas of her first-grade students. She ends up honoring all ideas and writing them down. Then she has students test each claim and evaluate each statement based on experimental evidence. These instructional skills can be applied to any content area.

The beginning of this video on demand, produced by Annenberg, shows Jennie, a Kindergarten teacher, lead children to make observations about leaves and form a **visual representation from their observations**. While content shown in other segments of the video does not apply to this content statement, watching the entire sequence demonstrates how Jennie wants to design grade-level-appropriate science activities. The instructional strategies demonstrated can be applied to any content statement.

Elsa, a Kindergarten teacher, is **implementing discovery-oriented activities** to make science more active in this video on demand produced by Annenberg. While the content is not applicable to this content statement, the instructional strategies demonstrated can be applied to any content area.

BACK TO INDEX
BACK TO K-8 INDEX

# Grade 1

## INTRODUCTION TO CONTENT STATEMENTS

### GRADE BAND THEME: OBSERVATIONS OF THE ENVIRONMENT

This theme focuses on helping students develop the skills for systematic discovery to understand the science of the physical world around them in greater depth by using scientific inquiry.

#### SCIENCE INQUIRY AND APPLICATION

During the years of PreK-4, all students must become proficient in the use of the following scientific processes, with appropriate **laboratory safety techniques**, to construct their knowledge and understanding in all science content areas:

- Observe and ask questions about the natural environment;
- Plan and conduct **simple investigations**;
- Employ simple equipment and tools to gather data and extend the senses;
- Use appropriate mathematics with data to construct reasonable explanations;
- Communicate about observations, investigations and explanations; and
- Review and ask questions about the observations and explanations of others.

#### STRANDS

**Strand Connections:** Energy is observed through movement, heating, cooling and the needs of living organisms.

| EARTH AND SPACE SCIENCE (ESS) | PHYSICAL SCIENCE (PS) | LIFE SCIENCE (LS) |
|---|---|---|
| **Topic: Sun, Energy and Weather** | **Topic: Motion and Materials** | **Topic: Basic Needs of Living Things** |
| This topic focuses on the sun as a source of energy and energy changes that occur to land, air and water. | This topic focuses on the changes in properties that occur in objects and materials. Changes of position of an object are a result of pushing or pulling. | This topic focuses on the physical needs of living things in Ohio. Energy from the sun or food, nutrients, water, shelter and air are some of the physical needs of living things. |
| **CONDENSED CONTENT STATEMENTS** | | |
| • The sun is the principal source of energy.<br>• The physical properties of water change. | • Properties of objects and materials can change.<br>• Objects can be moved in a variety of ways, such as straight, zigzag, circular and back and forth. | • Living things have basic needs, which are met by obtaining materials from the physical environment.<br>• Living things survive only in environments that meet their needs. |

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 1

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Sun, Energy and Weather**

This topic focuses on the sun as a source of energy and energy changes that occur to land, air and water.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Sun and Weather**

PreK-K: Weather changes every day, weather changes are short and long term, the sun is visible during the day and the position of the sun can change.

**Grade 1 Concepts**

Quantitative measurements must be used to observe and document the warming and cooling of air, water or soil. The length of time an object or material (including water) is exposed to sunlight and its resulting temperature must be observed, as should the amount of time for the object or material to cool down after it is taken out of the sunlight.

Appropriate tools and technology must be used to collect, compare and document data. Investigation and experimentation must be combined with explanation, questioning and discussion of the results and findings.

**Future Application of Concepts**

**Grade 2:** The relationship between energy and long- and short-term weather is introduced.

**Grades 3-5:** Renewable energy, forms of energy (e.g., heat, light, electrical energy), the solar system and patterns/cycles between the Earth and sun are explored.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Make a mini cold frame that can be used to protect plants from cold temperatures. Use recyclable materials, such as plastic bottles, milk jugs or cartons. Evaluate the placement of the cold frame to get the most autumn/ winter sunlight. Compare the results within the class or from class to class. Collect data (temperature, water, outside weather, amount of daily sunlight) to use in the comparison. | Build a model (kit) that can collect or use solar energy (simple, small devices, such as a solar oven, solar wind chimes or solar water heating devices). Ask: *What colors or materials work best? Where does the device work best? What can be done to make the device work better?* | Measure temperature changes of soil, water and air in different settings and/ or exposures to sunlight (e.g., select a grassy area in full sun, in partial sun or in shade and collect temperature readings). Make a graph, chart or table to record the data. Compare/contrast the results in writing or orally. | Recognize that sunlight warms water, air and soil. |
| | Experiment to compare the length of time it takes to heat samples of water/ soil/air to a specific temperature using sunlight. Discuss findings with the class. | | Identify the sun as a primary source of energy. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- *Beyond Penguins and Polar Bears* is an online magazine for K-5 teachers. It lists a number of misconceptions held by students regarding the sun and seasons, including that the sun is actually moving across the sky, rather than understanding it is the Earth that is moving. For more information, visit **http://beyondpenguins.nsdl.org/issue/column.php?date=May2008&departmentid=professional&columnid=professional!misconceptions**.
- For examples of misconceptions about the sun and energy, and resources to address misconceptions through investigation, visit **http://amasci.com/miscon/opphys.html**.
- NASA lists common misconceptions for all ages about the sun and the Earth at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**. Providing students with opportunities to experiment and explore the sun and solar energy can be tools to address the misconceptions that may be found at this grade level.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies *Patricia–Grade 1* and *Ingrid–Grade 1* are examples of how to develop student-led activities and investigations in science. Students' taking charge and being involved in their learning is essential in teaching science through inquiry.

BACK TO INDEX
BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 1

# EARTH AND SPACE SCIENCE (ESS)

**Topic: Sun, Energy and Weather**

This topic focuses on the sun as a source of energy and energy changes that occur to land, air and water.

### 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.

**Note: Water as a vapor is not introduced until grade 2; only solid and liquid water should be discussed at this level. A broader coverage of states of matter is found in grade 4. This concept builds on the PS Kindergarten strand pertaining to properties (liquids and solids).**

### CONTENT ELABORATION

**Prior Concepts Related to Water**

**PreK-K:** Water can be observed in many different forms; precipitation (rain, sleet, hail or snow) is a component of weather that can be measured.

**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. Water can change the shape of the land (e.g. moving soil or sand along the banks of a river or at the beach). Water also can be observed in the air as clouds, steam or fog, but this comment should be limited to observation only at this grade level (see **Note**).

Investigations (inside or outside) and experimentation must be used to demonstrate the changing properties of water. Use appropriate tools to test and measure water's weight, texture, temperature or size (e.g., compare measurements of water before and after freezing, examine the texture of snow or ice crystals using a hand lens) to document the physical properties.

**Future Application of Concepts**

**Grade 2:** Water as a vapor is introduced (water is present in the atmosphere).

**Grades 3-5:** Water is identified as a non-living resource that can be used for energy, common states of matter include liquids, solids and gases, Earth's surface has been changed by processes involving water and where water is found on Earth.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Make a mini cold frame that can be used to protect plants from cold temperatures. Use recyclable materials, such as plastic bottles, milk jugs or cartons. Evaluate the placement of the cold frame to get the most autumn/winter sunlight. Compare the results within the class or from class to class. Collect data (temperature, water, outside weather, amount of daily sunlight) to use in the comparison. | Investigate what happens to water as it freezes and thaws. Collect measurements, take temperature readings and record the length of time to freeze or thaw. Ask: ***What would happen when liquid water gets into rocks or if water boils and then freezes?*** **Note: This investigation can be incorporated into the cold frame design.** | Collect temperature readings during precipitation events. Make a graph, chart or table to compare the temperatures during rainfall, snow or sleet. Discuss the patterns that are observed. | Identify the different areas where water can be observed (e.g., lakes, stream, ponds, oceans, rain, snow, hail, sleet, fog).<br>Recognize that water can be a solid or a liquid. |
| | Investigate the physical differences between snow, crushed ice and/or liquid water (weight, temperature, texture). Ask: ***How much does one cup of snow/crushed ice/liquid water weigh? How does snow/crushed ice look through a hand lens?***<br>Discuss how these findings can apply to weather observations (e.g., ***how many inches of snow equal one inch of rain?***). | Differentiate between ocean water and fresh water. | Recall that heating and freezing water changes it from a solid to a liquid or a liquid to a solid. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Some examples of research questions to investigate through inquiry in the classroom or outside include: *How does the amount of water effect how fast water freezes? Why does a lake freeze faster and more completely than the ocean? Does hot water freeze faster or slower than cold water?*
- **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.
- **The Primary GLOBE Program** offers teacher-training programs and rich resource materials (including science-based storybooks) for K-4. Environmental stewardship and Earth systems science are emphasized.

## COMMON MISCONCEPTIONS

- A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study *Najwa and Pat–Grade 1* demonstrates engagement of special needs students in scientific inquiry. Strategies are provided to integrate students fully into the science investigations and activities.
- NSTA provides recommended resources to help identify existing misconceptions and help in using inquiry to allow students to uncover and address misconceptions. The resources include methods of using formative assessment effectively for misconceptions about water properties. Find it at **http://learningcenter.nsta.org/search.aspx?action=browse&text=page%20keeley&price=0&product=0&subject=42&topic=452&gradelevel=0&sort=Relevancy**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies *Patricia–Grade 1* and *Ingrid–Grade 1* are examples of how to develop student-led activities and investigations in science. Students' taking charge and being involved in their learning is essential in teaching science through inquiry.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 1

## LIFE SCIENCE (LS)

**Topic: Basic Needs of Living Things**

This topic focuses on the physical needs of living things in Ohio. Energy from the sun or food, nutrients, water, shelter and air are some of the physical needs of living things.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Interactions within Habitats**

**PreK-K:** Use macroscopic ways to identify living things. Living things have physical traits, which enable them to live in different environments.

**Grade 1 Concepts**

Earth has many different environmental conditions that support living things. The emphasis of this content statement is that living things meet their basic needs for survival by obtaining necessary materials from the environment. This includes, but is not limited to, temperature range, amount of water, amount of sunlight and available food sources. The environment includes both living (plants and animals) and nonliving (e.g., water, air, sunlight, nutrients) things.

Living things get the energy they require to respond, grow and reproduce from the environment. Observing energy being used in everyday situations can help promote understanding that living things get resources from the physical environment. **A detailed discussion of energy is not appropriate at this grade level** (see section heading E). Energy is not scientifically explained until grade 3.

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**.

Investigations about the types of living things that live in specific environments can be done virtually or in nature.

**Future Application of Concepts**

**Grade 2:** How living things impact the environment and how the environment impacts living things will be examined.

**Grade 3-5:** Life cycles of plants and animals will be explored.

**Grades 6-8:** Changes in environmental conditions can affect how beneficial a trait will be for survival and reproductive success of an individual or an entire species.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Using data from the Demonstrating Science Knowledge Investigation, design a bird feeder and blend of birdseed that will attract the most birds of one kind or the greatest variety of birds. Share designs, results and recommendations with an authentic audience. | Plan and implement a classroom investigation that answers the question: *Does the type of food influence what type of birds will come to a bird feeder?*<br><br>**Note: For a simple pinecone bird feeder, cover pinecones with vegetable shortening and coat with one type of food (e.g., black or striped sunflower seeds, millet, cracked corn, thistle).** | Based on observations of birds in the field, compare the food choices of birds in the study and create a chart to communicate findings. | Identify the basic survival needs of plants and animals (classroom pets, plants used in classroom experiments). At this grade level, students will not be assessed on common or scientific names of living things. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **The 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.
- Observe a variety of living things in the wild or the classroom and ask questions about how they survive. *How do they get food? Where do they live? What do they use for shelter?* The **Ohio Department of Natural Resources** website also provides information about observing animals in the wild and promotes safety for children and wildlife. The **Guide to Using Animals in the Classroom** explains legally which organisms may be collected.
- 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** website.
- ODNR-Division of Wildlife's **A to Z Species Guide** has photos, information, tracks and sounds of Ohio's wild animals
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In the activity *Surprise Terrarium*, students use a classroom terrarium to observe animal behavior and interactions. In *Beautiful Basics*, students list and organize needs of people, pets and wildlife.

### Career Connection

Students will design a zoo map that incorporates the climate and environmental characteristics of native habitats for each zoo animal. Lead a discussion to assist students by asking them probing questions such as, *What would a zoologist think about your design? Would an architect agree with your design?*. Identify careers that play a role in the process, such as:

- Zoologist: studying and understanding animals and their behavior.
- Animal Care Worker: managing animals, knowing animal dietary needs, understanding animal behavior.
- Veterinarian: managing the health and wellness of all animals, prescribing and administering medications, and performing surgeries as needed.
- Zoo Maintenance Workers: maintaining the zoo grounds.
- Botanist: work with plants.
- Landscape Architect or Designer: designing animal habitats that are reflective of the animal's natural environment with plants and materials found in different biomes.

## COMMON MISCONCEPTIONS

- **Benchmarks for Science Literacy** contains a detailed discussion of energy. Scroll to section heading E for detailed information of grade-appropriate exposure to energy.
- Students may think that food must come from outside an organism. They may also think that fertilizers are actually plant food. They fail to understand that plants make sugars and starches through the process of photosynthesis and that light is essential for plant survival. **Beyond Penguins and Polar Bears** is an online magazine for K-5 teachers that provides information for misconceptions about plants.
- The **Annenberg Media series Essential Science for Teachers** can be used to provide greater insight to misconceptions children hold about living things and energy. Classroom videos and lessons are provided to help students avoid these misconceptions.
- The Annenberg Media series, *Essential Science for Teachers*, offers **Life Science: Sessions 1 and 2**, which provide greater insight to misconceptions children hold about living, dead and nonliving things and strategies to address those misconceptions.
- **AAAS' Benchmarks 2061 Online, Chapter 15**, 5e, *Flow of Matter and Energy*, highlights that children think plants get their food from the environment rather than making it internally from water and air. Students often have difficulty in identifying the source of energy for plants and animals.

BACK TO INDEX

BACK TO K-8 INDEX

## DIVERSE LEARNERS

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

- Many ***Project Wild*** activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. In ***Surprise Terrarium*** students use a classroom terrarium to observe animal behavior and interactions. Information about upcoming ***Project Wild*** workshops is available on the **ODNR Website**.

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study ***Jeanie–K*** is an example of how to teach young children about observations of the living environment.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 1

## LIFE SCIENCE (LS)

**Topic: Basic Needs of Living Things**

This topic focuses on the physical needs of living things in Ohio. Energy from the sun or food, nutrients, water, shelter and air are some of the physical needs of living things.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Interactions within Habitats**

**PreK-K:** Use macroscopic ways to identify living things. Living things have physical traits, which enable them to live in different environments.

**Grade 1 Concepts**

Plants and animals require resources from the environment. The focus at this grade level is on macroscopic interactions and needs of common living things (plants and animals).

Animals require basic habitat components, including food, water, cover and space. The amount and distribution of the basic components will influence the types of animals that can survive in an area. Food sources might include insects, plants, seeds or other animals. Water sources may be as small as drops of dew found on grass or as large as a lake or river. Animals need cover for many life functions, including nesting, escaping from predators, seeking shelter from the elements on a cold winter day and resting. Animals also need space in which to perform necessary activities such as feeding or raising young. Seasonal changes affect the resources available to living things (e.g., grasses are not as available in winter as they are in summer).

The needs of plants include room to grow, temperature range, light, water, air, nutrients and time (growing season). The amount and distribution of these will influence the types of plants that can survive in an area. Observations of seasonal changes in temperature, liquid water availability, wind and light must be applied to the effect of seasonal changes on local plants.

**Future Application of Concepts**

**Grade 2:** This concept expands to include interactions between organisms and the physical environment in which the organisms or the physical environment are changed.

**Grade 3-5:** The fact that organisms have life cycles that are part of their adaptations for survival in their natural environment builds upon this concept.

**Grades 6-8:** In any particular biome, the number, growth and survival of organisms and populations depend on biotic and abiotic factors.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Using data from the Demonstrating Science Knowledge investigation, design a bird feeder and blend of birdseed that will attract the most birds of one kind or the greatest variety of birds. Share designs, results and recommendations with an authentic audience. | Plan and implement a classroom investigation that answers the question: *Does the type of food influence what type of birds will come to a bird feeder?*<br><br>**Note: For a simple pinecone bird feeder, cover pinecones with vegetable shortening and coat with one type of food (e.g., black or striped sunflower seeds, millet, cracked corn, thistle).** | Explain, draw, journal and photograph what happens to local living and nonliving environments over the course of a school year. If resources are not available to draw or photograph, seasonal photographs taken in Ohio can be found on the Ohio Department of Natural Resources **website**. | Match pictures of local plants and animals to the environment in which they can be found.<br><br>Photographs of Ohio plants and animals can be found on the Ohio<br><br>Department of Natural Resources **website**. |
| | Plan and implement a classroom investigation to monitor a specific plant or animal over a long period (a semester or the school year). Observe and record the behavioral and physical changes that occur in that animal or plant. | | |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **The 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.
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. If explicit connections between environment and organism survival are made, the following *Project Wild* activities could be helpful: in *Wildlife is Everywhere*, children make observations and understand that wildlife is all around us; in *Field Study Fun*, children investigate a field study plot to observe plant and animal interactions over time; in *Urban Nature Search* students make observations of habitats that are found around their schoolyard and can be done seasonally to illustrate changes; and in *Surprise Terrarium* students use a classroom terrarium to observe animal behavior and interactions.

## COMMON MISCONCEPTIONS

- The Annenberg Media series **Essential Science for Teachers** can be used to provide greater insight to misconceptions children hold about living things and energy. Classroom videos and lessons are provided to help students avoid these misconceptions.
- **Benchmarks for Science Literacy** contains a detailed discussion of energy. Scroll to section heading E for detailed information of grade-appropriate exposure to energy.
- The Annenberg Media series, *Essential Science for Teachers,* offers **Life Science: Session 2**, which provides greater insight to misconceptions children hold about classifying living things and strategies to address those misconceptions.
- **AAAS' Benchmarks 2061 Online, Chapter 15**, *Interdependence of Life*, highlights that students understand simple food links between organisms but they think of organisms as independent of each other but dependent on people to supply them with food and shelter.

## DIVERSE LEARNERS

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

- Perkins School for the Blind, Watertown, MA, offers webcast videos including the video chapter *Accessible Science – Life Science*, which encourages the use of terrariums with visually handicapped students instead of aquariums. Find it at **http://support.perkins.org/site/PageServer?pagename=Webcasts_Acessible_Science_Life_Science**.
- Many *Project Wild* activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. In *Surprise Terrarium*, students use a classroom terrarium to observe animal behavior and interactions. In *Wildlife is Everywhere*, children make observations and understand that wildlife is all around us. In *Field Study Fun*, children investigate a field study plot to observe plant and animal interactions over time. In *Urban Nature Search* students make observations of habitats that are found around their schoolyard and can be done seasonally to illustrate changes. Information about upcoming *Project Wild* workshops is available on the **ODNR Website**.

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study ***Najwa and Pat–Grade 1*** is an example of how to teach young children about the requirement of living things.

BACK TO INDEX
BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 1

## PHYSICAL SCIENCE (PS)

**Topic: Motion and Materials**

This topic focuses on the changes in properties that occur in objects and materials. Changes of position of an object are a result of pushing or pulling.

### 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.

**Note 1: Changes in temperature are a result of changes in energy.**

**Note 2: Water changing from liquid to solid and from solid to liquid is found in ESS grade 1.**

### CONTENT ELABORATION

**Prior Concepts Related to Properties of Objects and Materials**

**PreK-K:** Objects are things that can be seen or felt. Properties can be observed using tools or one's senses and can be used to sort objects. Comparisons of objects are made as a precursor to measurement.

**Grade 1 Concepts:**

Materials can be exposed to conditions that change some of their properties, but not all materials respond the same way. The properties of a material can change as it interacts with other materials. Heating and cooling changes some, but not all, properties of materials.

Some materials can be a liquid or solid at room temperature and may change from one form to the other with a change in the temperature. A liquid may turn into a solid when frozen. A solid may turn into a liquid when heated. The amount of the material in the solid or liquid remains the same. Investigations and experiments (may include virtual investigations) must be conducted to explore property changes of objects and materials.

Parts of objects have specific properties that allow them to work with other parts to carry out a particular function. Something may not work well or at all if a part of it is missing, broken, worn out, mismatched or misconnected. Toys that can be assembled from several parts can be investigated when one or more of the parts are missing.

**Note: Emphasis is placed on observations. Concepts of thermal energy, atoms and heat transfer are inappropriate at this grade.**

**Future Application of Concepts**

**Grade 2:** Water can change from liquid to vapor in the air and from vapor to liquid (ESS).

**Grades 3-5:** Matter is defined. Measurements of weight and liquid volume are made. Properties of solids, liquids and gases, and phase changes are explored. During any change, including phase changes, the total mass* remains constant. The sum of the mass* of the parts of an object is equal to the mass* of the entire object.

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate the multiple ways properties of objects and materials change.** | | | |
| Using the findings (about shapes) from the Demonstrating Science Knowledge section, design and build a small boat out of recycled materials and can float in water for a specific period of time. | Plan and implement an investigation to test various clay shapes (e.g., a clay ball, a clay block, flattened clay with edges) to determine how shape affects the ability of a material to float or sink in water. | Compare different ways of changing an object or material (e.g., tearing, heating, cooling, mixing, taking apart, putting together). | Recognize and classify various types of changes that objects or materials can go through to change observable properties (e.g., freezing, melting, tearing, wetting). |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

## COMMON MISCONCEPTIONS

- Although two materials are required for the dissolving process, children tend to focus only on the solid and they regard the process as melting. (Driver, Squires, Rushworth & Wood-Robinson, 1994, p.80)
- **Heat is a substance.**
- Cold is the opposite of heat and is another substance.
- **Melting/freezing** and boiling/condensation are often understood only in terms of water.
- **When things** dissolve, they disappear.
- Melting and dissolving are confused.
- Cold can be transferred.

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

From a time of about 11:40, this video on demand produced by Annenberg shows how a teacher can lead children to make **observations about changes in snow** under different conditions. While content shown during other segments of the video does not apply to this content statement, watching the entire sequence demonstrates how Jennie learns to incorporate inquiry-based science activities into her lessons. These instructional strategies can be applied to any content area.

Starting at a time of about 17:50 on this video on demand produced by Annenberg, children **explore changes of matter** by mixing different colors of liquid drops. Allowing students to do their own experiments increases enthusiasm for science and encourages creativity. Later they mix colors using different colors of transparent cellophane. While content shown during other segments of the video does not apply to this content statement, watching the entire sequence demonstrates how Elsa learns to incorporate appropriate science experiences with lessons that teach social, motor and communication skills in her bilingual classroom. These instructional strategies can be applied to any content area.

In this beginning of this video on demand produced by Annenberg, Ingrid explores what students already know about **phases of matter** through a class discussion and journal writing. She then has students investigate the properties of phases and leads a class discussion to come to a consensus about what is important to know about solids, liquids and gases. While content shown during other segments of the video does not apply to this content statement, watching the entire sequence demonstrates how Ingrid, a beginning first-grade teacher, is working on incorporating student ideas into her lessons. Initially, she struggles with what to do with incorrect ideas. She ends up writing all ideas down and has students test the ideas and evaluate each idea based on evidence. While not all of the content is applicable to this content statement, the instructional strategies demonstrated can be applied to any content area.

Patricia, a first-grade teacher, explores the benefits and challenges of having children **work in small groups**, as opposed to a single classroom group, in this video on demand produced by Annenberg. She guides students to better social skills and learns to become more comfortable with less structure. While not all of the content is applicable to this content statement, the instructional strategies demonstrated can be applied to any content area.

Another video on demand produced by Annenberg features Najwa and Pat, first-grade teachers who are working to develop their students' science skills of **prediction and observation**. While not all of the content is applicable to this content statement, the instructional strategies demonstrated can be applied to any content area.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 1

## PHYSICAL SCIENCE (PS)

**Topic: Motion and Materials**

This topic focuses on the changes in properties that occur in objects and materials. Changes of position of an object are a result of pushing or pulling.

### 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.

**Note: Changes in motion are a result of changes in energy.**

### CONTENT ELABORATION

**Prior Concepts Related to Motion**

**PreK-K:** Vibrating objects can cause sound.

**Grade 1 Concepts:**

The position of an object is described by comparing its location relative to another object (e.g., in front, behind, above, below). Objects can be moved and their positions are changed.

Objects can move in a straight line (like a dropped coin falling to the ground) or a circle (like a pinwheel) or back and forth (like a swing) or even in a zigzag pattern. Objects near Earth fall to the ground unless something holds them up.

Object motion can be faster, slower or change direction by pushing or pulling the object. Experimentation, testing and investigations of different ways to change the motion of different objects (such as a ball, a pinwheel or a kite) must be used to demonstrate movement.

**Note 1: Scientific definitions and calculations of speed are inappropriate at this grade.**

**Note 2: Force is a push or pull between two objects and energy is the property of an object that can cause change. A force acting on an object can sometimes result in a change in energy. The differences between force and energy will be developed over time and are not appropriate for this grade.**

**Future Application of Concepts**

**Grade 2:** Forces are necessary to change the motion of objects.

**Grades 3-5:** The amount of change in movement of an object is based on the mass* of the object and the amount of force exerted.

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate ways to make a ping-pong ball move in a zigzag pattern.** | | | |
| Design, construct and test a device that will cause a ping-pong ball to move in a zigzag pattern.<br>Test and evaluate the effectiveness of the different devices made by different groups in the class.<br>Redesign the device for greater effectiveness. | | Compare the designs and their effectiveness from different devices made by different groups in the class. | Recognize that to speed up, slow down or change the movement direction of an object, a push or pull is needed. |
| **Investigate ways to change the motion of an object.** | | | |
| | Implement a scientific investigation to determine: ***How can a ball be made to speed up (slow down or change direction)?*** With the class, list all the ways that were found. | Orally present the results of the experiments to the class.<br>Make a written list of all the observations from the class.<br>Compare the different methods used by different groups in the class.<br>Represent the different motions of a toy in words, pictures and diagrams. | Recognize that to speed up, slow down or change the movement direction of an object, a push or pull is needed.<br>Identify an object's position with respect to another object or the background. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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 videos 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.
- Have children choose a movement and race to the other side of classroom/gym.

## COMMON MISCONCEPTIONS

- **The location** of an object can be described by stating its distance from a given point, ignoring direction.
- The only natural motion is for an object to be at rest.
- If an object is at rest, no forces are acting on the object.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

Ingrid, a beginning first-grade teacher, is working on **incorporating children's ideas** into her lessons in this video on demand produced by Annenberg. Initially, she struggles with what to do with incorrect ideas. She ends up writing all ideas down and has students test the ideas and evaluate each idea based on evidence. While not all of the content is applicable to this content statement, the instructional strategies demonstrated can be applied to any content area.

*Force and Motion* is a series of videos produced by Annenberg that is designed for teachers to improve their knowledge of forces and motion and gives ideas for teaching the concepts to elementary learners. This particular lesson shows how first-grade students can use balls in different ways to **explore different types of motion**.

Patricia, a first-grade teacher, explores the benefits and challenges of having children **work in small groups**, as opposed to a single classroom group, in this video on demand produced by Annenberg. She guides students to better social skills and learns to become more comfortable with less structure. While not all of the content is applicable to this content statement, the instructional strategies demonstrated can be applied to any content area.

Another video on demand produced by Annenberg features Najwa and Pat, first-grade teachers who are working to develop children's science skills of **prediction and observation**. While not all of the content is applicable to this content statement, the instructional strategies demonstrated can be applied to any content area.

BACK TO INDEX
BACK TO K-8 INDEX

# Grade 2

## INTRODUCTION TO CONTENT STATEMENTS

### GRADE BAND THEME: OBSERVATIONS OF THE ENVIRONMENT

This theme focuses on helping students develop the skills for systematic discovery to understand the science of the physical world around them in greater depth by using scientific inquiry.

#### SCIENCE INQUIRY AND APPLICATION

During the years of PreK-4, all students must become proficient in the use of the following scientific processes, with appropriate **laboratory safety techniques**, to construct their knowledge and understanding in all science content areas:

- Observe and ask questions about the natural environment;
- Plan and conduct **simple investigations**;
- Employ simple equipment and tools to gather data and extend the senses;
- Use appropriate mathematics with data to construct reasonable explanations;
- Communicate about observations, investigations and explanations; and
- Review and ask questions about the observations and explanations of others.

#### STRANDS

**Strand Connections:** Living and nonliving things may move. A moving object has energy. Air moving is wind and wind can make a windmill turn. Changes in energy and movement can cause change to organisms and the environments in which they live.

| EARTH AND SPACE SCIENCE (ESS) | PHYSICAL SCIENCE (PS) | LIFE SCIENCE (LS) |
|---|---|---|
| Topic: **The Atmosphere**<br>This topic focuses on air and water as they relate to weather and weather changes that can be observed and measured. | Topic: **Changes in Motion**<br>This topic focuses on observing the relationship between forces and motion. | Topic: **Interactions within Habitats**<br>This topic focuses on how ecosystems work by observations of simple interactions between the biotic/living and abiotic/nonliving parts of an ecosystem. Just as living things impact the environment in which they live, the environment impacts living things. |
| **CONDENSED CONTENT STATEMENTS** | | |
| • The atmosphere is made up of air.<br>• Water is present in the air<br>• Long- and short-term weather changes occur due to changes in energy. | • Forces change the motion of an object. | • Living things cause changes on Earth.<br>• Some kinds of individuals that once lived on Earth have completely disappeared, although they were something like others that are alive today. |

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 2

# EARTH AND SPACE SCIENCE (ESS)

**Topic: The Atmosphere**

This topic focuses on air and water as they relate to weather and weather changes that can be observed and measured.

### 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.

**Note: Air is introduced in ESS Kindergarten and can be linked to PS and LS.**

### CONTENT ELABORATION

**Prior Concepts Related to Air and Atmosphere**

**PreK-1:** Wind is moving air, air is a nonliving substance that surrounds Earth, wind can be measured and sunlight warms the air.

**Grade 2 Concepts**

In the earlier grades, wind is measured but not with a numerical value or directional data (e.g., wind may be moving faster/slower than yesterday and is coming from a different direction). Wind can change the shape of the land (e.g. sand dunes, rock formations). In grade 2, wind can be measured with numeric value and direction (e.g., wind speed is 6 mph, wind direction is west to east).

Air takes up space (has volume) and has mass*. Heating and cooling of air (transfer of energy) results in movement of air (wind). The direction and speed of wind and the air temperature can be measured using a variety of instruments, such as windsocks, weather vanes, thermometers or simple anemometers. Weather events that are related to wind (e.g., tornadoes, hurricanes) are included in this content. 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.

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

**Future Application of Concepts**

**Grades 3-5:** Renewable energy, air pollution and wind can weather and erode Earth's surface.

**Grades 6-8:** Thermal energy transfers in the atmosphere, air currents and global climate patterns.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design and construct an instrument that can measure wind speed and wind direction. Properties of the chosen materials and design must be evaluated as part of the testing and decision making process. Demonstrate final product to the class. | Plan and implement an experiment to illustrate that air has mass* and takes up space (has volume).<br><br>*While mass is the scientifically correct term to use in this context, the **NAEP 2009 Science Framework** (page 27) recommends using the more familiar term "weight" in the elementary grades with the distinction between mass and weight being introduced at the middle school level. In Ohio, students will not be assessed on the differences between mass and weight until Grade 6. | Take measurements of wind speed and wind direction each day for two weeks. Record the measurements and plot results on a graph. Find and interpret patterns (e.g., when the wind comes from the south the speed is lower than when the wind comes from the north). | Recognize that air takes up space and can be weighed. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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.

## COMMON MISCONCEPTIONS

- For examples of misconceptions that young children have about air and the atmosphere, and resources to address misconceptions through investigation, visit **http://amasci.com/miscon/opphys.html**.
- A common misconception regarding air and atmosphere is that air is nothing. It is important to provide activities for students that show properties of the atmosphere and air. For ways to allow students to demonstrate that air actually has mass* and takes up space (volume), visit **http://weather.about.com/od/lessonplanselementary/ht/air_volume.html** and **http://weather.about.com/od/lessonplanselementary/ht/air_has_mass.htm**.

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

BACK TO INDEX

BACK TO K-8 INDEX

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study *Richard and Jo-Ann–Grade 2* provides an example of integrating mathematics and science into a science class.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 2

# EARTH AND SPACE SCIENCE (ESS)

**Topic: The Atmosphere**

This topic focuses on air and water as they relate to weather and weather changes that can be observed and measured.

### 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.

**Note: This concept builds upon the changing properties of water from ESS grade 1.**

### CONTENT ELABORATION

**Prior Concepts Regarding Relationship of Water and Air**

**PreK-1:** Wind and water are observable parts of weather, sunlight warms water and air, and the physical properties of water can change (liquid to solid and solid to liquid).

**Grade 2 Concepts**

The physical properties of water (from grade 1) are expanded to include water vapor (water in the air). The different states of water are observed in weather events, nature and/or classroom investigations. The concepts of condensation and evaporation are explored through experimentation and observation. The different parts of the water cycle are explored and discussed. The emphasis at this grade level is investigating condensation and evaporation at depth, not memorizing the water cycle itself.

The focus is on investigation and understanding, not on the vocabulary. Cloud formation and types of clouds are introduced as they relate to weather, storm fronts and changing weather. Again, the emphasis is not in naming cloud types, but in relating the characteristics of the clouds with weather. Factors such as water contamination/pollution can be introduced within this content statement as it relates to pollutants that can enter waterways through precipitation, evaporation and condensation.

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 this content statement.

**Future Application of Concepts**

**Grades 3-5:** The states and conservation of matter, weathering and erosion of Earth's surface, seasonal changes and energy transfer are explored.

**Grades 6-8:** The hydrologic cycle, transfer of energy between the hydrosphere and lithosphere, and biogeochemical cycles are studied.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design and construct a community in an aquarium that is enclosed and has soil, plants and water. Test the effects of the sun on evaporation and condensation rates and the air and/or water temperature. Evaluate the findings and discuss with the class. | Plan and implement an experiment to investigate what factors contribute to water evaporating into the atmosphere. Discuss the different results with the class to generate a list of all the possible methods that were tested. | Compare the different appearances of clouds (shapes, sizes, shades of white/ gray). Document the observations over a period of time to find if there is a relationship between the characteristics of the clouds and the weather (storms, precipitation types and/or amounts). | Recognize that clouds, steam, fog, hail, snow, sleet and hail are examples of water in the atmosphere. |
| | Plan and implement an experiment to investigate what happens when pollution is in a body of water that evaporates. Use a simple model that utilizes sediment, vinegar or vegetable oil as a contaminant. | | Recall that water can change from liquid to vapor and/or vapor to liquid. |
| | | | Identify clouds as droplets of water and the droplets can combine and form into raindrops. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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).

## COMMON MISCONCEPTIONS

- It is difficult for young students to understand fully the process of condensation and how clouds form. The misconception that clouds are like cotton and/or have a solid "feel" to them can be addressed by investigations and experiments that are directly related to condensation and cloud formation. For a classroom-exploration example of making clouds in a bottle that can demonstrate cloud consistency, see **http://eo.ucar.edu/kids/images/AtmoExp1.pdf**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study *Richard and Jo-Ann–Grade 2* provides an example of integrating mathematics and science into a science class.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 2

## EARTH AND SPACE SCIENCE (ESS)

**Topic: The Atmosphere**

This topic focuses on air and water as they relate to weather and weather changes that can be observed and measured.

### 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.

**Note: Discussion of energy at this grade level should be limited to observable changes.**

### CONTENT ELABORATION

**Prior Concepts Related to Weather Changes**

**PreK-1:** Weather changes during the day and from day to day. Weather changes can be long- or short-term. Weather changes can be measured and have patterns.

**Grade 2 Concepts**

Weather is a result of energy change. Heating and cooling of water, air and land (from sunlight) are directly related to wind, evaporation, condensation, freezing, thawing and precipitation. Weather patterns (long-term) and fronts (short-term) can be documented through consistent measuring of temperature, air pressure, wind speed and direction, and precipitation. Some forms of severe weather can occur in specific regions/areas, scientists forecast severe weather events.

Weather data must be measured, collected and documented over a period of time and then connected to observable forms of energy (e.g., wind causes a sailboat to move, the sun can heat the sidewalk). Experiments and investigations (both inside and outside of the classroom) must be used to demonstrate the connection between weather and energy.

**Note: Density and convection should not be introduced at this grade level.**

**Future Application of Concepts**

**Grades 3-5:** Changes in energy and changing states of matter are explored in greater depth through applications other than weather. Renewable resources (energy sources) and changes in Earth's environment through time are examined.

**Grades 6-8:** Changes of state are explained by molecules in motion, kinetic and potential energy. The hydrologic cycle and thermal energy transfers between the hydrosphere and atmosphere are studied.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design and construct an **instrument** that can measure wind speed and wind direction. Materials must be evaluated to determine the best material for the specific purpose. Discuss/share findings with the class or as a class. | 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. | Based on student collected data, outline the relationship between wind and cloud changes vs. changes in weather from one season to another season. Outline relationships in writing or through a class discussion, oral presentation or graphic representation. | Recall that weather changes occur due to energy changes. |
| | Plan and implement an investigation to determine the factors or characteristics that contribute to the changes in day-to-day weather (storms, fronts). Compare average annual temperatures between cites at the same latitude, but at different elevations or proximity to large lakes or the ocean. | Research the long-term or short-term changes in weather that occur at specific weather fronts (e.g., ask: ***What happens when warm, moist air collides with cold, dry air?***) Represent the findings graphically or present findings to the class. | Recognize that a weather front is an area where different air masses collide. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **The National Center for Atmospheric Research** provides support and educational materials for teachers and students to learn about the connection between the atmosphere and weather.
- Preparing to teach about the atmosphere requires keeping updated on new discoveries and innovative ideas to teach about air, wind 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.
- Newspapers can be used to provide actual real-time weather data to use in the classroom.

## COMMON MISCONCEPTIONS

- NASA lists common misconceptions for all ages about the sun and the Earth, including weather and seasons, at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- For examples of misconceptions that young children have about energy, weather and the sun, and resources to address misconceptions through investigation, visit **http://amasci.com/miscon/opphys.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study *Richard and Jo-Ann–Grade 2* provides an example of integrating mathematics and science into a science class.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 2

## LIFE SCIENCE (LS)

**Topic: Interactions within Habitats**

This topic focuses on how ecosystems work by observations of simple interactions between the biotic/living and abiotic/nonliving parts of an ecosystem. Just as living things impact the environment in which they live, the environment impacts living things.

### 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.

**Note: At this grade level, discussion is limited to changes that can be easily observed.**

### CONTENT ELABORATION

**Prior Concepts Related to Interactions within Habitats**

**PreK-1:** Observe macroscopic characteristics of living things. Including basic survival needs of living things, how living things get resources from the environment and how available resources vary throughout the course of a year.

**Grade 2 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 (soil, rocks, water). 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.

The impact and actions of living things must be investigated and explored. The focus is not limited to human interaction with the environment (such as resource use or recycling). Observe earthworm compost bins, ant farms and weeds growing on vacant lots.

**Future Application of Concepts**

**Grades 3-5:** Changes that occur in an environment can sometimes be beneficial and sometimes harmful.

**Grades 6-8:** Matter is transferred continuously between one organism to another and between organisms and their physical environment.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design and build (with teacher help) a working worm composting bin or an ant farm (whichever is most appropriate for the classroom) that can be used to observe activity and actions of the worms or ants.<br><br>**Note: The project selected should be built based on student ideas not from a readymade kit.** | Plan and conduct an investigation that will compare identical soil samples, one with earthworms and one without earthworms, over an extended period of time. Include data about temperature, amount of moisture, appearance, materials added, materials removed and/ or odor.<br><br>**Note: For this grade level, the presence of bacteria and fungi are not included. Students may be able to see fungi fruiting bodies, but would not be able to see the fungal cells without using tools and content knowledge that are above this grade level.** | Represent data obtained from classroom investigations or real-world examples in a chart, table or pictograph (e.g., make a table of data obtained from soil samples with earthworms as compared to soil samples without earthworms). | Recognize scientifically accurate facts in stories about environmental change caused by living things. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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.
- Observe a plot of land that has been abandoned and make predictions about how the appearance of that property will change if there is no human intervention. If possible, document the changes throughout the year.
- 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?*
- **Growing Up WILD: Exploring Nature with Young Children** is a curricular resource that is available only through attending their training sessions; the activities provided are aligned to Ohio's science standards. In *Wildlife is Everywhere*, children make observations and understand that wildlife is all around us. In Field Study Fun, children investigate a field study plot to observe plant and animal interactions over time. In *Wiggling Worms*, children learn about and observe earthworms.
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In the activity *Urban Nature Search*, students make observations of habitats that are found around their schoolyard. This activity can be done seasonally to illustrate changes. In *Surprise Terrarium*, students use a classroom terrarium to observe animal behavior and interactions.

## COMMON MISCONCEPTIONS

- The Annenberg Media series **Essential Science for Teachers** can be used to provide greater insight to misconceptions children hold about living things and energy. Classroom videos and lessons are provided to help students avoid these misconceptions.
- **AAAS' Benchmarks 2061 Online, Chapter 15**, 5e, *Flow of Matter and Energy*, illustrates that students may think that dead organisms simply rot away. They do not realize that material is converted into other materials by decomposing agents.

## DIVERSE LEARNERS

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

- Many *Project Wild* activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. In the activity *Urban Nature Search*, students make observations of habitats that are found around their schoolyard. This activity can be done seasonally to illustrate changes. In *Surprise Terrarium*, students use a classroom terrarium to observe animal behavior and interactions. Information about upcoming *Project Wild* workshops is available on the **ODNR Website**.

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The Annenberg video *Richard and Joann–Grade 2* provides examples of ways to integrate science and mathematics in second grade classrooms. Be careful of to check for local food safety rules and student allergies before using food in a classroom.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 2

## LIFE SCIENCE (LS)

**Topic: Interactions within Habitats**

This topic focuses on how ecosystems work by observations of simple interactions between the biotic/living and abiotic/nonliving parts of an ecosystem. Just as living things affect the environment in which they live, the environment impacts living things.

### 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

**Prior Concepts Related to Interactions within Habitats**

**PreK-1:** Living things have physical traits, which enable them to live in different environments.

**Grade 2 Concepts**

Fossils are physical traces of living things that are preserved in rock. By examining fossils, it can determined that some fossils look similar to plants and animals that are alive today, while others are very different from anything alive today.

Extinction refers to the disappearance of the last member of a living thing's kind. Sometimes extinction is described as the dying out of all members of the living thing's kind. Extinction generally occurs as a result of changed conditions to which the living thing's kind is not suited. Some kinds of living things that once lived on Earth have completely disappeared (e.g., the **Sabertooth Cat**, Smilodon). Some kinds of living things that once lived on Earth are something like others that are alive today (e.g., **horses**).

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, websites, books, local parks and museums can be used to visualize past environments and the organisms that lived in them.

**Future Application of Concepts**

**Grade 3-5:** Fossils will be addressed in more detail.

**Grades 6-8:** This concept will be expanded to providing a partial explanation of biodiversity.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Test the durability of fossils made in the Demonstrating Science Knowledge section. Compare the fossils for strength, ease of breakage and resistance to dissolving in water. | Make "fossils" of animal tracks using different kinds of soils (silt, sand, clay). Plaster of Paris can be used to make a cast or mold. Ask: *Which soil worked best to make the fossil and why?* For a procedure that can be altered for use by different grades, see **http://geophysics.esci.keele.ac.uk/earthlearningidea/PDF/66_Trailmaking.pdf.** | Compare the macroscopic features of organisms (e.g., an elephant) that are alive today with those of similar extinct organisms (e.g., a mammoth). | Name an organism that was once abundant in the local area that now is extinct. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The 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. **Science Daily** provides a rich source of information on the relationship between mammoths and elephants.
- Several sites provide instructions for making fossils. The following sites provide background information for construction but do not meet the requirement of the content statement: **http://www.michigan.gov/documents/deq/p06create_304664_7.pdf**; **http://www.geology.siu.edu/outreach/making_fossils.htm**; and **http://www.nps.gov/miss/forteachers/upload/brjfossils.pdf**.

## COMMON MISCONCEPTIONS

- **Science Daily** provides a rich source of information on the relationship between mammoths and elephants.
- The Annenberg Media series *Essential Science for Teachers:* **Life Science: Session 2***: Children's Ideas* provides greater insight to misconceptions children hold about classifying living things and strategies to address those misconceptions.
- **AAAS' Benchmarks 2061 Online, Chapter 15**, *The Research Base*, provides a comprehensive list of research findings that served as guidelines for the development of this book. Scroll down to *Classification of Life*.

BACK TO INDEX

BACK TO K-8 INDEX

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The Annenberg video *Richard and Joann–Grade 2* provides examples of ways to integrate science and mathematics in second-grade classrooms. Be careful to check for local food safety rules and student allergies before using food in a classroom.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 2

## PHYSICAL SCIENCE (PS)

**Topic: Changes in Motion**

This topic focuses on observing the relationship between forces and motion.

### 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.

**Note: At this grade level, gravitational and magnetic forces should be introduced through observation and experimentation only. The definitions of these forces should not be the focus of the content statements.**

### CONTENT ELABORATION

**Prior Concepts Related to Forces and Motion**

**PreK-1:** Vibrating objects are observed producing sound. Motion is described as a change in an object's position. Forces are pushes and pulls that can change the motion of objects.

**Grade 2 Concepts:**

Forces are needed to change the movement (speed up, slow down, change direction or stop) of an object. Some forces may act when an object is in contact with another object (e.g., pushing or pulling). Other forces may act when objects are not in contact with each other (e.g., magnetic or gravitational).

Earth's gravity pulls any object toward it, without touching the object. Static electricity also can pull or push objects without touching the object. Magnets can pull some objects to them (attraction) or push objects away from them (repulsion). Gravity, static electricity and magnets must be explored through experimentation, testing and investigation at this grade level.

For a particular object, larger forces can cause larger changes in motion. A strong kick to a rock is able to cause more change in motion than a weak kick to the same rock. Real-world experiences and investigations must be used for this concept.

**Note 1: Introducing fields, protons, electrons or mathematical manipulations of positive and negative to explain observed phenomena are not appropriate at this grade level.**

**Note 2: There often is confusion between the concepts of force and energy. Force can be thought of as a push or pull between two objects and energy as the property of an object that can cause change. A force acting on an object can sometimes result in a change in energy. The differences between force and energy will be developed over time and is not appropriate at this grade level.**

**Note 3: Charges and poles are often confused. It is important to emphasize they are different.**

**Future Application of Concepts**

**Grades 3-5:** The amount of change in movement of an object depends on the mass* of the object and the amount of force exerted.

**Grades 6-8:** Speed is defined and calculated. The field concept for forces at a distance is introduced.

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| | **Investigate how noncontact forces can affect motion.** | | |
| Design and construct a device to move a matchbox car from one position to another without touching it.<br>Test the device and evaluate the design. | Plan and implement a scientific experiment to explore the effects some objects have on others even when the two objects might not touch (e.g., magnets). | Pictorially represent the design.<br>Compare the designs and their effectiveness from the different groups in the class. | Identify a noncontact force that can affect the motion of an object. |
| | **Investigate ways to change the motion of objects.** | | |
| | Plan and implement a scientific experiment to explore how to change how something is moving (e.g., push, pull, speeding up, slowing down, changing direction, stopping). | Represent the observations from the experiment orally and in writing.<br>Explain the relationship between forces and motion. | Give two examples of how a force can be applied to an object. |
| | Predict the changes in motion that a moving object or an object at rest experiences when acted on by a force (e.g., push, pull, gravity). | Compare what is needed to get stationary objects moving and what is needed to get moving objects to stop. | Identify contact/noncontact forces that affect motion of an object (e.g., gravity, magnetic force, contact).<br>Recognize that greater changes in the motion of an object require larger forces. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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 videos 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**. The subsequent quiz is not aligned to the content statement.
- Observe attractions and repulsions involved with electrical (e.g., static electricity on a balloon or sweater) and magnetic forces (e.g., compass or bar magnet).

### Career Connection

Lead a discussion around the types of careers that design vehicles or devices that respond to or are impacted by force (e.g. airplanes, boats, trucks). Students will explore a career related to various types of transportation, including those connected to the military, through available resources in the school or classroom library. Then, they will depict their findings in a drawing.

## COMMON MISCONCEPTIONS

- **The only natural** motion is for an object to be at rest.
- If an object is at rest, no forces are acting on the object.
- Only animate objects can exert a force. Thus, if an object is at rest on a table, no forces are acting on it.
- Force is a property of an object.
- An object has force and when it runs out of force, it stops moving.
- A force is needed to keep an object moving with a constant speed.
- **Gravity only acts on things when they are falling.**
- Only animate things (people, animals) exert forces; passive ones (tables, floors) do not exert forces.

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

Starting at a time of about 8:50, children **study magnetic forces** on this video on demand produced by Annenberg. First, children gain experiential knowledge by sorting objects into things that can be picked up by magnets and those that cannot. Then, they explore whether the force of magnets can go through paper, water, wood and cloth. While content shown during other segments of the video does not apply to this content statement, watching the entire sequence demonstrates how Elsa learns to incorporate appropriate science experiences with lessons that teach social, motor and communication skills in her bilingual classroom. These instructional strategies can be applied to any content area.

Richard and Jo-Ann are second-grade teachers who **are integrating math and science** in this video on demand produced by Annenberg. Although not all of the content is directly aligned to this content statement, the strategies could be applied to any content. Especially interesting segments start at times of about 13:50 and 23:50 where children are asked to invent formulas for paste and cola. These segments are examples of how inquiry and design can be infused in an elementary classroom.

Linda is featured on this video on demand produced by Annenberg. She is a resource teacher who **models inquiry-based science** lessons for Grades 2-4 teachers in her large urban district. Although not all of the content is directly aligned to this content statement, the strategies could be applied to any content.

BACK TO INDEX
BACK TO K-8 INDEX

# Grade 3

## INTRODUCTION TO CONTENT STATEMENTS

### GRADE BAND THEME: INTERCONNECTIONS WITHIN SYSTEMS

This theme focuses on helping students recognize the components of various systems and then investigate dynamic and sustainable relationships within systems using scientific inquiry.

#### SCIENCE INQUIRY AND APPLICATION

During the years of PreK-4, all students must become proficient in the use of the following scientific processes, with appropriate **laboratory safety techniques**, to construct their knowledge and understanding in all science content areas:

- Observe and ask questions about the natural environment;
- Plan and conduct **simple investigations**;
- Employ simple equipment and tools to gather data and extend the senses;
- Use appropriate mathematics with data to construct reasonable explanations;
- Communicate about observations, investigations and explanations; and
- Review and ask questions about the observations and explanations of others.

#### STRANDS

**Strand Connections:** Matter is what makes up all substances on Earth. Matter has specific properties and exists in different states. Earth's resources are made of matter. Matter can be used by living things and can be used for the energy they contain. There are many different forms of energy. Each living component of an ecosystem is composed of matter and uses energy.

| EARTH AND SPACE SCIENCE (ESS) | PHYSICAL SCIENCE (PS) | LIFE SCIENCE (LS) |
|---|---|---|
| **Topic: Earth's Resources** | **Topic: Matter and Forms of Energy** | **Topic: Behavior, Growth and Changes** |
| This topic focuses on Earth's resources. While resources can be living and nonliving, within this strand, the emphasis is on Earth's nonliving resources, such as water, air, rock, soil and the energy resources they represent. | This topic focuses on the relationship between matter and energy. Matter has specific properties and is found in all substances on Earth. Heat is a familiar form of energy that can change the states of matter. | This topic explores life cycles of organisms and the relationship between the natural environment and an organism's (physical and behavioral) traits, which affect its ability to survive and reproduce. |
| **CONDENSED CONTENT STATEMENTS** | | |
| • Earth's nonliving resources have specific properties.<br>• Earth's resources can be used for energy.<br>• Some of Earth's resources are limited. | • All objects and substances in the natural world are composed of matter.<br>• Matter exists in different states, each of which has different properties.<br>• Heat, electrical energy, light, sound and magnetic energy are forms of energy. | • Offspring resemble their parents and each other.<br>• Individuals of the same kind differ in their traits and sometimes the differences give individuals an advantage in surviving and reproducing.<br>• Plants and animals have life cycles that are part of their adaptations for survival in their natural environments. |

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 3

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Earth's Resources**

This topic focuses on Earth's resources. While resources can be living and nonliving, within this strand, the emphasis is on Earth's nonliving resources, such as water, air, rock, soil and the energy resources they represent.

### 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.

**Note 1: Rock classification is not the focus for this grade level; this is found in grade 6. At this grade, the actual characteristics of rocks can be used to sort or compare, rather than formal classification.**

**Note 2: Properties of air and water have been addressed in PreK.**

### CONTENT ELABORATION

**Prior Concepts Related to Properties of Nonliving Resources**

**PreK-2:** Objects and materials can be sorted and described by their properties. Living things are different than nonliving things. Properties of objects and materials can change. Water and air have specific properties that can be observed and measured.

**Grade 3 Concepts**

The properties of air and water are introduced in the early elementary grades, so the focus at the third-grade level is on soil and rocks. Air and water are present within rocks and soil. Air and water also play an important role in the formation of rocks and soil. All are considered nonliving resources.

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.

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

**Future Application of Concepts**

**Grades 4-5:** The characteristics of both soil and rock are related to the weathering and erosion of soil and rock, which result in changes on Earth's surface. The general characteristics of Earth are studied.

**Grades 6-8:** Further exploration of soil and rock classification is found with the expansion of instruction to minerals and mineral properties.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design and construct a pond, water garden or a wetland environment in a terrarium. Evaluate different soil types to ensure that the chosen soil is able to hold water and support plant life. Present the explanation of the process and the findings to the class.<br><br>**Note: Must use the soil properties investigated to make these determinations.** | Plan and implement an investigation to test specific properties of different types of soil, such as ability to absorb (hold) water, matching/designating soil color, the ability for water to pass through the soil, the filtering properties of soil.<br><br>**Note: A similar investigation can be conducted for the characteristics of rocks.** | Make a chart, identification key or a local soil map that can be used to interpret soil composition (sand, silt, clay organic material) and/or compare soil types (based on soil properties).<br><br>**Note: A similar chart or map can be made for the characteristics of rocks.** | Identify rock, soil, air and water as examples of non-living resources.<br><br>Recognize that soil can have different texture, composition or color depending on the environment in which it formed. |
| | Plan and build a simple sediment tube that can demonstrate how sand, silt, clay and organic material settle in water. Based on the findings, ask: *Which soil type would create muddy water in a stream? Which soil type would wash away faster/farther? What properties of soil contribute to these observations?* | Make a dichotomous key to organize different types of rocks by grain size, texture, color or patterns. Graphically represent and clarify the sorted results. | Recall that rocks can be sorted based on characteristics such as grain-size (texture), color and patterns. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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.

## COMMON MISCONCEPTIONS

- Funded by the National Science Foundation, ***Beyond Penguins and Polar Bears*** is an online magazine for K-5 teachers. It provides some common misconceptions about sorting rocks at early elementary levels, which can begin at the preschool level when children may think that size or color should be used to identify types of rocks. For common misconceptions about rocks and minerals, visit **http://beyondpenguins.nsdl.org/issue/column.php?date=September2008&departmentid=professional&columnid=professional!misconceptions**.
- Students often think soil is alive. While living things live in soil and organic soil is composed of once-living things, they need to understand that soil itself is not alive.
- Students may think soil type is determined by color. Soil type is actually determined based on particle size. Color is dependent upon the rock type from which the soil is formed over time.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study ***Erien, Year One–Grade 5*** is an example of how to conduct soil profiling in an elementary class setting. Of particular interest are the questioning techniques that Erien uses with her students to generate interest.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 3

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Earth's Resources**

This topic focuses on Earth's resources. While resources can be living and nonliving, within this strand, the emphasis is on Earth's nonliving resources, such as water, air, rock, soil and the energy resources they represent.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Energy from Earth's Resources**

**PreK-2:** Wind is moving air, water and wind have measurable properties, and sunlight warms the air and water

**Grade 3 Concepts**

Distinguishing between renewable and nonrenewable resources through observation and investigation is the emphasis for this content statement. This can be connected to learning about the different forms of energy (PS grade 3). Electrical circuit or solar panel models can be used to demonstrate different forms of energy and the source of the energy. The conservation of energy is explored within the content statement Some of Earth's resources are limited.

Specific energy sources in Ohio are introduced, such as fossil fuels found in Ohio, new energy technologies, and the development of renewable energy sources within Ohio. Ohio must be compared to other states regarding energy sources.

**Future Application of Concepts**

**Grades 4-5:** Energy is explored through electrical energy, magnetic energy, heat, light and sound.

**Grades 6-8:** The formation of coal, oil and gas, kinetic and potential energy, thermal energy, energy conservation, energy transfer (includes renewable energy systems) and additional examination of nonrenewable resources are studied.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Research, design and/or construct a model of a simple energy collection system for a specific location (use locations in Ohio or areas near water/ prairies/rivers/mountains). Provide a selection of everyday materials for the model (rather than a preplanned kit), such as PVC piping and Mylar to make a windmill or water wheel to allow student-led investigation and design. | Develop a plan to determine the most effective method of collecting renewable energy (e.g., shapes/number/materials used in wind or water turbines, locations that allow solar panels to collect the most energy from the sun). | Research the efficiency and cost of different types of energy resources (renewable and/or nonrenewable).<br>Compare and contrast the findings. Present or discuss findings with the class. | Recognize the differences between renewable and nonrenewable energy. Be able to provide examples of each. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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** website. 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.
- Combine/integrate energy resources with PS grade 3 to learn about different forms of energy.

### Career Connection

Students will explore the concept of "green jobs", by identifying careers, organizations, and policies that reflect the conservation of energy or utilization of alternative energy sources. They may focus on aspects of green jobs such as wind, solar, and wave, energy, renewable materials, transportation, and buildings and structures that conserve energy. Additional information about green jobs is available at: **http://www.bls.gov/green/**.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- **Misconceptions about fossil fuels** and energy resources are common. Use effective questioning to help understand preconceptions that elementary students may have about energy resources and address the misconceptions.
- Students may have difficulty differentiating between renewable and nonrenewable resources. Providing investigations and local (Ohio) examples can help students make the connections needed for this understanding. For a teacher fact sheet with important examples to support this content statement and to ensure that misconceptions are addressed, see **http://www.epa.gov/osw/education/quest/pdfs/unit1/chap1/u1_natresources.pdf**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study ***Erien, Year One–Grade 5*** is an example of how to conduct soil profiling in an elementary class setting. Of particular interest are the questioning techniques that Erien uses with her students to generate interest.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 3

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Earth's Resources**

This topic focuses on Earth's resources. While resources can be living and nonliving, within this strand, the emphasis is on Earth's nonliving resources, such as water, air, rock, soil and the energy resources they represent.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Limit of Earth's Resources**

**PreK-2:** Properties of objects and materials can change. The amount of exposure to sunlight affects the warming of air, water and land. Living things acquire resources from nonliving components. Resources are necessary for living things.

**Grade 3 Concepts**

Within third grade, the focus is on the different types of Earth's resources, how they are used and how they can be conserved. Scientific data should be used to evaluate and compare different methods of conservation (e.g., effectiveness of different kinds of recycling such as paper vs. metal). The concentration must be the science behind the conservation of resources and why certain resources are limited. Reducing or limiting the use and/or waste of resources should be emphasized (rather than concentrating only on recycling of resources).

**Future Application of Concepts**

**Grades 4-5:** Conservation of matter, environmental changes through Earth's history and erosion (loss of resources/ contamination) are introduced.

**Grades 6-8:** Common and practical uses of soil, rock and minerals (geologic resources), biogeochemical cycles, global climate patterns and interactions between the spheres of Earth (Earth Systems) are found.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design and carry out a plan to reduce the use of specific resources at the school, school district or local community. Data collection can include water use, paper use, soil erosion, composting (food waste), hazardous waste and examination of the types of programs available in the local area. Once data is analyzed and plans are chosen, present findings to school and/or community officials. | Plan and implement an investigation to collect and analyze data pertaining to the school's recycling rate to determine what types of materials have a high recycling rate and which have low rates (and reasons why). Graph and present the findings to school administrators or community officials. | Research different types of recycling (paper, plastics, metals, glass) and make a comparison table to document methods, effectiveness, recycling rates, benefits and/or problems. | Recognize that some of Earth's resources are limited and need to be conserved. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The **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.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- A common misconception is that as long as an item is recycled there is no need to limit the use of that item. It is important that students know that it is always better to reduce or limit the use of a resource than to use and recycle. Recycling requires energy resources and also can create other unintended issues (due to the recycling process). By investigating the efficiency of recycling, students can begin to understand that many resources are limited and cannot be effectively recycled after use.
- **Misconceptions about fossil fuels** and energy resources are common. Use effective questioning to help understand preconceptions that elementary students may have about energy resources and address the misconceptions.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study ***Erien, Year One–Grade 5*** is an example of how to conduct soil profiling in an elementary class setting. Of particular interest are the questioning techniques that Erien uses with her students to generate interest.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 3

## LIFE SCIENCE (LS)

**Topic: Behavior, Growth and Changes**

This topic explores life cycles of organisms and the relationship between the natural environment and an organism's (physical and behavioral) traits, which affect its ability to survive and reproduce.

### 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.

Some behavioral traits are learned through interactions with the environment and are not inherited.

### CONTENT ELABORATION

**Prior Concepts Related to Behavior, Growth and Changes**

**PreK-2:** Similarities and differences exist among individuals of the same kinds of plants and animals.

**Grade 3 Concepts**

Organisms are similar to their parents in appearance and behavior but still show some variation. Although the immature stages of some living things may not resemble the parents, once the offspring matures, it will resemble the parent. At this grade level, the focus is on establishing, through observation, that organisms have a reliable mechanism for ensuring that offspring resemble their parents. It is not appropriate or necessary to introduce the genetic mechanisms involved in heredity, however, care should be taken to avoid introducing the misconception that the individual organism has a way to select the traits that are passed on to the next generation. As part of the study of the life cycle of organisms, the physical appearance of the adults will be compared to the offspring (e.g., compare butterflies to determine if offspring look exactly like the parents).

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 webcam) can be used to observe animals in their natural or human-made environments.

**Future Application of Concepts**

**Grades 6-8:** These observations will build to a description and understanding of the biological mechanisms involved in ensuring that offspring resemble their parents. Cell Theory will be introduced which will explore how cells come from pre-existing cells and new cells will have the genetic information of the old cells. The details of reproduction will be outlined.

**Note: Human genetic study is not recommended since not all students may have information available from their biological parents.**

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design an enriched environment that will support a classroom pet. Provide for all of its needs.<br><br>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 wellbeing." Find more about animal environment enrichment at **http://nationalzoo.si.edu/SCBI/AnimalEnrichment/default.cfm**. | Conduct a real-time observational study of a familial grouping of organisms.<br><br>Use webcams 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<br><br>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**. | Based on data from Demonstrating<br><br>Science Knowledge, develop a chart that compares features such as stages of development, food sources, where it is found in the environment, and physical appearance to emphasize the similarity and differences between offspring and parents. | Give examples of variations among individuals of a local population of dandelions (e.g., height, color, weight). |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Use webcams 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 webcams 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.
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In the *Aquatic Project Wild activity, Are You Me?* students match picture cards into juvenile and adult aquatic animal pairs.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- The Annenberg Media series **Essential Science for Teachers** can be used to provide greater detail on life cycles within the elementary curriculum and misconceptions students may have about various traits.

## DIVERSE LEARNERS

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

- Many ***Project Wild*** activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. In the ***Aquatic Project Wild activity, Are You Me?*** students match picture cards into juvenile and adult aquatic animal pairs.

## CLASSROOM PORTALS

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

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**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 3

## LIFE SCIENCE (LS)

**Topic: Behavior, Growth and Changes**

This topic explores life cycles of organisms and the relationship between the natural environment and an organism's (physical and behavioral) traits, which affect its ability to survive and reproduce.

### 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.

**Note: The focus is on the individual, not the population. Adaption is not the focus at this grade level.**

### CONTENT ELABORATION

**Prior Concepts Related to Behavior, Growth and Changes**

**PreK-2:** Similarities and differences exist among individuals of the same kinds of plants and animals. Living things have physical traits and behaviors that influence their survival.

**Grade 3 Concepts**

Organisms have different structures and behaviors that serve different functions. Some plants have leaves, stems and roots; each part serves a different function for the plant. Some animals have wings, feathers, beaks; each part serves a different function for the animals. The observation of body parts should be limited to gross morphology and not microscopic or chemical features. Comparison across species is not appropriate at this grade level; only observation of variation within the same species is expected. This content statement can be combined with the observation of the life cycles of organisms and/or the observation of the similarity between offspring and parents.

There may be variations in the traits that are passed down that increase the ability of organisms to thrive and reproduce. Some variations in traits that are passed down may reduce the ability of organisms to survive and reproduce. Some variations in traits that are passed down may have no appreciable effect on the ability of organisms to survive and reproduce. Variations in physical features among animals and plants can help them survive in different environmental conditions. Variations in color, size, weight, etc., can be observed as the organism develops.

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.

**Future Application of Concepts**

**Grades 4-5:** Changes in the environment may benefit some organisms and be a detriment to other organisms.

**Grades 6-8:** The reproduction of organisms will explain how traits are transferred from one generation to the next.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| 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.htm**. | Plan and conduct an experiment to find out the optimal conditions for seed germination. Include in the conclusions scientific information about why not all seeds germinated. | Write a report explaining how the behavioral or physical characteristic is an advantage of a specific animal or plant for surviving in its environment (e.g., ***what adaptations does a pine tree have for living in colder environments?***) | Name some physical features of plants and animals that are associated with the environment in which they live (e.g., coloration, location of eyes, type of feet). |
| | | Conduct a comparative study of a population of plants in the school yard, measure and compare some of the following: root size (width and depth) leaf size (length and width) flower color, number of petals, time of year when plant blooms, number of seeds produced or when seeds are produced. | |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- *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.
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In the activity *Thicket Game* students illustrate animal survival adaptations through a game of hide and seek. In *Quick Frozen Critters* students illustrate animal survival adaptations through a game of freeze tag.

## COMMON MISCONCEPTIONS

- The Annenberg Media series **Essential Science for Teachers** can be used to provide greater detail on life cycles within the elementary curriculum and misconceptions students may have about various traits.

## DIVERSE LEARNERS

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

- Many *Project Wild* activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. In the activity *Thicket Game* students illustrate animal survival adaptations through a game of hide and seek. In *Quick Frozen Critters* students illustrate animal survival adaptations through a game of freeze tag.

## CLASSROOM PORTALS

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

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**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 3

## LIFE SCIENCE (LS)

**Topic: Behavior, Growth and Changes**

This topic explores life cycles of organisms and the relationship between the natural environment and an organism's (physical and behavioral) traits, which affect its ability to survive and reproduce.

### 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.

**Note: The names of the stages within the life cycles are not the focus.**

**Note: New organisms are produced by the old ones.**

### CONTENT ELABORATION

**Prior Concepts Related to Behavior, Growth and Changes**

**PreK-2:** Plants and animals have variations in their physical traits that enable them to survive in a particular environment. Some organisms exhibit seasonal behaviors that enable them to survive environmental conditions and changes.

**Grade 3 Concepts**

Plants and animals have life cycles that are adapted to survive in distinct environments (e.g., bean plants can be grown inside during winter, but cannot grow outside in the winter). Most life cycles start with birth, then progress to growth, development, adulthood, reproduction and death. The process can be interrupted at any stage. The details of the life cycle are different for different organisms.

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**.

**Future Application of Concepts**

**Grades 4-5:** Organisms perform a variety of roles in an ecosystem.

**Grades 6-8:** The structure and organization of organisms and the necessity of reproduction for the continuation of the species will be detailed.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| 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.htm**. | Plan and conduct an experiment to find out the optimal conditions for seed germination. Include in the conclusions scientific information about why not all seeds germinated. | Explain why some animals have offspring in the spring and some plants produce seeds in the fall. | Given labeled photographs of stages of animal or plant life cycles, place them in sequence from egg to adult. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- ODNR-Division of Wildlife's **A to Z Species Guide** has photos, information, tracks and sounds of Ohio's wild animals
- Explore how organisms reproduce, grow and find shelter in habitats around the world. The **National Geographic website** 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**, or other grade-appropriate sources of information on the life cycle of organisms **http://www.learningscience.org/lsc1blifecycles.htm**. 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**.

## COMMON MISCONCEPTIONS

- The Annenberg Media series **Essential Science for Teachers** can be used to provide greater detail on life cycles within the elementary curriculum and misconceptions students may have about various traits.

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

Session 5 of the Annenberg Media series ***Essential Science for Teachers: Life Science*** provides information about how children can learn about the variations of living things and offers classroom footage to illustrate implementation at **http://www.learner.org/resources/series179.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 3

## PHYSICAL SCIENCE (PS)

**Topic: Matter and Forms of Energy**

This topic focuses on the relationship between matter and energy. Matter has specific properties and is found in all substances on Earth. Heat is a familiar form of energy that can change the states of matter.

### CONTENT STATEMENT

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

Matter takes up space and has mass*.

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

### CONTENT ELABORATION

**Prior Concepts Related to Matter**

**PreK-2:** Objects are things that can be seen or felt. Properties of objects may be described, measured and sorted. The physical properties of water change as observed in weather. Air has mass* and takes up space (ESS).

**Grade 3 Concepts:**

Objects are composed of matter and matter has observable properties. Matter is anything that has mass* and takes up space. All solids, liquids and gases are made of matter.

Volume is a measure of the amount of space an object takes up. Volumes of liquids can be measured in metric units with a beaker or graduated cylinder. Weight is a measure of gravity (how strongly Earth's gravity pulls the object toward Earth). Weight is measured using a scale. For any given location, the more matter there is in an object, the greater the weight. Opportunities to investigate and experiment with different methods of measuring weight and liquid volume must be provided.

Objects are made of smaller parts, some too small to be seen even with magnification. Matter continues to exist, even when broken into pieces too tiny to be visible.

**Notes: Atomic and subatomic nature of matter is not appropriate at this grade. Math standards at this grade limit volume measurements to liquids measured to the nearest whole number. This document follows the recommendations of the NAEP 2009 Science Framework (see page 27) for dealing with the concepts of mass and weight.**

**Future Application of Concepts**

**Grades 4-5:** The mass* and total amount of matter remains the same when it undergoes a change, including phase changes. The sum of the mass* of the parts of an object is equal to the weight (mass) of the entire object.

**Grades 6-8:** The atomic model is introduced. Properties are explained by the arrangement of particles.

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Draw conclusions to characterize types of matter based on observations made from experimental evidence.** | | | |
| Investigate the parts of a (classroom-made) lava lamp exhibit when various conditions (e.g., temperature, size of bottle) are changed and record the results. Compare how the findings can apply to a real-world scenario (e.g., responding to an oil spill in different climates or parts of the world).<br><br>**Note: This is not a kit. For directions on constructing the lava lamp, visit http://www.sciencebob.com/experiments/lavalamp.php** | Given three different items, measure as many properties for each item as possible. Record the measurements for each item on a separate index card. Switch samples with another group and identify which set of measurements belong with which item. | Distinguish between weight and volume. Represent the differences in words and visual models. | Name observable differences between the three states of matter. |
| | | Investigate an ice balloon and the various conditions that affect the rate at which the ice melts, using the **Ice Balloon Investigation**. | Recognize that matter continues to exist when broken into pieces too tiny to be visible. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- From a time of 3:15 to 16:40, this video on demand produced by Annenberg shows individual interviews with children that highlight **common misconceptions about what is matter** (e.g., air is not matter) and ways that this can be addressed in the classroom.
- Kind (2004) cites that students think matter has no permanent aspect. When matter disappears from sight (e.g., when sugar dissolves in water), it ceases to exist.
- Students often think of solids at matter, but not liquids and gases (AAAS, 1993).
- Kind (2004, p.8) cites that children do not reason consistently. They may use sensory reasoning on some occasions and logical reasoning on others. Sensory experience dominates in cases where matter is not visible.
- Students often think that:
  - **Measurement is only linear.**
  - Any quantity can be measured as accurately as you want.
  - Some objects cannot be measured because of their size or inaccessibility.
  - The five senses are infallible.
  - **Gases are not matter** because most are invisible.
  - Gases do not have mass.
  - Air and oxygen are the same gas.
  - Helium and hot air are the same gas.
  - Materials can only exhibit properties of one state of matter.
  - Melting/freezing and boiling/condensation are often understood only in terms of water.
  - Steam is visible water gas molecules.
  - **Materials can** only exhibit properties of one state of matter.
  - Melting and dissolving are confused.
  - Dew formed on the outside of glass comes from the inside of the glass.
  - Gases are not matter because most are invisible.
  - Weight and volume, which both describe an amount of matter, are the same property.
  - Steam is water vapor over boiling water.

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

Starting at a time of 9:55 on this video on demand produced by Annenberg, children **test a mixture of unknown powders** to identify what is in the mixture. Children use data and procedures from previous investigations to solve the problem. Jean, an inclusion teacher, talks about classroom management and organization for messy lab activities and the benefits of cooperative learning. The video shows how the teacher helped students who were having difficulties. Notice that the students are asked continually to support their claims with evidence.

Jean, an **inclusion teacher**, helps third-grade students who are having difficulties during classroom inquiry activities in this video on demand, produced by Annenberg. She has been trying to develop multi-sensory approaches to learning science to help a diversity of students, including ESL, inclusion students and other special needs students. Jean talks about classroom management and organization for messy lab activities and the benefits of cooperative learning. The video shows how an inclusion teacher can be used in this lesson.

Select Video 10, *Linda–Grades 2-4*, to see a resource teacher who models **inquiry-based science lessons** in her large urban district. Although not all of the content is directly aligned to this content statement, the strategies could be applied to any content.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 3

## PHYSICAL SCIENCE (PS)

**Topic: Matter and Forms of Energy**

This topic focuses on the relationship between matter and energy. Matter has specific properties and is found in all substances on Earth. Heat is a familiar form of energy that can change the states of matter.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Matter**

**PreK-2:** Materials can be sorted by properties. The physical properties of water change as observed in weather (ESS).

**Grade 3 Concepts:**

Gases, liquids and solids are different states of matter that have different properties. Liquids and solids do not compress into a smaller volume as easily as do gases. Liquids and gases flow easily, but solids do not flow easily. Solids retain their shape and volume (unless a force is applied). Liquids assume the shape of the part of the container that it occupies (retaining its volume). Gases assume the shape and volume of its container.

Heating may cause a solid to melt to form a liquid, or cause a liquid to boil or evaporate to form a gas. Cooling may change a gas into a liquid or cause a liquid to freeze and form a solid.

Conducting experiments or investigations that demonstrate phase changes, such as the melting or freezing of substances other than water (e.g., vinegar, vegetable oil, sugar, butter), must be used to reinforce the concept that materials other than water also go through phase changes.

**Note 1: Purdue University provides a table that can help in differentiating the properties of solids, gases and liquids. Teaching about the atomic structure as related to the phases is not appropriate for this grade level.**

**Note 2: Only solids, liquids and gases are appropriate at this grade, even though other phases have been identified. The differences between boiling and evaporation are not dealt with at this grade.**

**Future Application of Concepts**

**Grades 4-5:** The amount of mass* and matter remains the same during phase changes.

**Grades 6-8:** Atomic theory is introduced. Properties of solids, liquids and gases are related to the spacing and motion of particles. Thermal energy and temperature are related to the motion of particles.

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Draw conclusions to characterize types of matter based on observations made from experimental evidence.** | | | |
| Investigate the parts of a (classroom-made) lava lamp exhibit when various conditions are changed and record the results. Consider how the findings can apply to a real-world scenario (e.g., responding to an oil spill in different climates or parts of the world).<br><br>**Note: For directions on constructing the lava lamp, visit http://www.sciencebob.com/experiments/lavalamp.php** | Predict the fastest way for ice to form. Design an investigation to determine what parameters ensure the fastest formation (e.g., change temperature of the starting water using cold, room-temperature and very hot water, condition the starting water with salt or sugar, change the starting water by adding food coloring). | Explain why which data sets (e.g., descriptions of various physical properties) match given substances focusing on specific states of matter. | Recognize three different states of matter. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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**. The optional section dealing with heating the gas further is not aligned to this content statement.
- *Gases Around Us* is an **interactive simulation** from BBC Schools that demonstrates that **gases expand** to fill a container.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- **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 from a time of 7:00 to 16:40 shows individual student interviews that highlight common misconceptions about states of matter (e.g., air is not matter) and ways that they can be addressed in the classroom.
- Children often think that:
  - **Measurement is only linear.**
  - Any quantity can be measured as accurately as you want.
  - Some objects cannot be measured because of their size or inaccessibility.
  - The five senses are infallible.
  - **Gases are not matter** because most are invisible.
  - Gases do not have mass.
  - Air and oxygen are the same gas.
  - Helium and hot air are the same gas.
  - Materials can only exhibit properties of one state of matter.
  - Melting/freezing and boiling/condensation are often understood only in terms of water.
  - Steam is visible water gas molecules.
  - **Materials can** only exhibit properties of one state of matter.
  - Melting and dissolving are confused.
  - Dew formed on the outside of glass comes from the inside of the glass.
  - Gases are not matter because most are invisible.
  - Weight and volume, which both describe an amount of matter, are the same property.
  - Steam is the visible cloud of water vapor over boiling water.
- One study showed that some children, ages 5-13, tend to associate solids with rigid materials (Stavy & Stachel, 1984). They regard powders as liquids and any non-rigid materials, such as a sponge or a cloth, as being somewhere in between a solid and liquid (Driver, Squires, Rushworth & Wood-Robinson, 1994).
- Children can classify liquids more easily than they can solids, perhaps because liquids are less varied in their physical characteristics (Kind, 2004).
- Students' explanation of powders as liquids is often "because they can be poured." Reasons for non-rigid objects being neither solid nor liquid are because they "are soft," "crumble," or "can be torn." Children characterized the state of matter of a material according to its macroscopic appearance and behavior with the result that solids are associated with hardness, strength and an inability to bend (Driver et al., 1994).
- Students' understanding of boiling comes before their understanding of evaporation (Keeley, 2005). Driver (1994) states that from a sample of students ages 6-8, 70 percent understood that when water boils, vapor comes from it and that the vapor is made of water; the same students did not recognize that when a wet surface dries, the water turns to water vapor.
- Because students confuse heat and temperature as being the same, they believe that the longer something is heated, the hotter it gets and the boiling point increases the longer it is allowed to boil (Driver et al., 1994).

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

Beginning at a time of about 0:50, this video on demand produced by Annenberg explores the **properties of gases, liquids and solids**. Students observe phase changes of water from ice to steam, discuss what they know so far, test the properties of Oobleck to classify its state. Notice the questioning strategy: ***What do you think about that? and Give me reasons for your thinking.***

Ingrid, a first-grade teacher, has children explore the **properties of solids, liquids and gases** through playful explorations. Before the activities, she conducts a class discussion and journal writing to determine what the children already know. After the activities, she surveys children's thoughts about their experiences in a class discussion to come to a consensus about the important properties of solids, liquids and gases.

**Essential Science for Teachers: Physical Science Session 1: Matter** is another video on demand produced by Annenberg. It explores the concept of matter with elementary children and teachers. The segment from a time of 32:40 to 54:40 shows individual interviews with children about states of matter. Classroom activities show that categories between the states of matter are not always clear-cut. Demonstrations show the differences between liquids and gases.

Jean, a veteran teacher who feels ill prepared to teach science, is featured on this video on demand produced by Annenberg. The beginning of the video shows her leading a classroom lesson in which students **explore different states of matter**. Notice her questioning strategy: ***What do you think about that? and Give me reasons for your thinking.*** The remainder of the video does not align to this standard but shows how she develops multi-sensory approaches to learning science to help a diversity of students, including ESL, inclusion students and other special needs students. Jean talks about classroom management and organization for messy lab activities and the benefits of cooperative learning. The video also shows how an inclusion teacher can be used in this lesson.

Select Video 10, *Linda–Grades 2-4*, to see a resource teacher who models **inquiry-based science lessons** for teachers in her large urban district. Although not all of the content is directly aligned to this content statement, the strategies could be applied to any content.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 3

## PHYSICAL SCIENCE (PS)

**Topic: Matter and Forms of Energy**

This topic focuses on the relationship between matter and energy. Matter has specific properties and is found in all substances on Earth. Heat is a familiar form of energy that can change the states of matter.

### 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.

**Note: The different forms of energy that are outlined at this grade level should be limited to familiar forms of energy that a student is able to observe.**

### CONTENT ELABORATION

**Prior Concepts Related to Sound, Energy and Motion**

**PreK-2:** Vibrations are associated with sound. An object is in motion when its position is changing. Forces change the motion of an object. Sunlight is the principal source of energy on Earth and warms Earth's land, air and water (ESS). Weather changes occur due to changes in energy (ESS). Living things require energy (LS). Plants get energy from sunlight (LS).

**Grade 3 Concepts:**

Examples of energy causing motion or creating change include a falling rock causing a crater to form on the ground, heating water causing water to change into a gas, light energy from the sun contributing to plant growth, electricity causing the blades of a fan to move, electrically charged objects causing movement in uncharged objects or other electrically charged objects, sound from a drum causing rice sitting on the drum to vibrate, and magnets causing other magnets and some metal objects to move.

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

**Note 1: It is not appropriate at this grade level to explore the different types of energy in depth or use wave terminology when discussing energy. These will be developed at later grades.**

**Note 2: There often is confusion between the concepts of force and energy. Force can be thought of as a push or pull between two objects and energy as the property of an object that can cause change. If forces actually push or pull something over a distance, then there is an exchange of energy between the objects. The differences between force and energy will be developed over time and are not appropriate for this grade level.**

**Note 3: The word "heat" is used loosely in everyday language, yet it has a very specific scientific meaning. Usually what is called heat is actually "thermal or radiant energy." An object has thermal energy due to the random movement of the particles that make up the object. Radiant energy is that which is given off by objects through space (e.g., warmth from a fire, solar energy from the sun). "Heating" is used to describe the transfer of thermal or radiant energy to another object or place. Differentiating between these concepts is inappropriate at this grade. This document uses the same conventions as noted in the NAEP 2009 Science Framework (see page 29) where "heat" is used in lower grades. However, the word "heat" has been used with care so it refers to a transfer of thermal or radiant energy. The concept of thermal energy, as it relates to particle motion, is introduced in grade 6.**

**Future Application of Concepts**

**Grades 4-5:** Processes of energy transfer and transformation are introduced. Heat, electrical energy, light and sound are explored in more detail.

**Grades 6-8:** Energy is classified as kinetic or potential. The concepts of conservation of energy and thermal energy as it relates to particle motion are introduced.

BACK TO INDEX

BACK TO K-8 INDEX

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPT | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate ways a pot of warm water can cause motion or create change.** | | | |
| | Explore ways that a pot of warm water can cause change (e.g., warm water can cause butter to melt, pouring water on a sand structure can cause the structure to change shape). | Explain how warm water can cause motion or create change. | Recognize that energy can cause motion or create change. |
| Design, construct and test a small boat or aircraft that can move in different directions (or against the flow of air/water) in nature. Document the forms of energy and resulting motion as the boat or aircraft is being demonstrated to an authentic audience. | | Explain how a magnet can cause motion or create change. Examples of possible answers include: a magnet can cause other magnets and some metallic items to move toward it, a magnet can cause other magnets to move away from it. | Identify objects with energy in the environment (e.g., moving water, windmill, water wheel, sunlight) and determine what types of energy they have. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- *Science in Focus: Energy* is a series of videos on demand produced by Annenberg to help teachers **understand children's preconceptions about energy** and what is important to understand about energy. Some of the content, like forces and work, are not directly related to this content statement. However, teachers need a good understanding of the differences and relationships between these important concepts.
- Write and illustrate a children's book about energy. Use observable forms of magnetic energy, electrical energy, light, sound and heat. Include descriptions and illustrations. Share the finished product with students at a different grade level.
- Combine and integrate the ESS grade 3 Energy Resources section. Building a solar oven can be used to illustrate that light energy can cause changes in temperature.

## COMMON MISCONCEPTIONS

- Do not use resources that claim "free energy" or "perpetual motion machines" since these perpetuate myths that violate the law of conservation of energy. These are especially common when dealing with magnetic energy.
- Students do not realize that light, heat and sound are forms of energy and can cause things to happen.
- **Energy is a thing**, an object or something that is tangible.
- **Energy is confined** to some particular origin, such as what we get from food or what the electric company sells.
- Energy is a thing. This is a fuzzy notion, probably because of the way we talk about the amount of energy; it is difficult to imagine an amount of an abstraction.
- The terms "energy" and "force" are interchangeable.
- **Heat is a substance.**
- Heat is not energy.
- *Science in Focus: Energy* is a series of videos on demand produced by Annenberg dealing with energy. This segment deals with **heat**. The video series is designed to make teachers aware of common student misconceptions. While not all the concepts addressed are appropriate to be taught at this grade level, being aware of them can help avoid perpetuating common misconceptions.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

Jean, an **inclusion teacher**, helps third-grade students who are having difficulties during classroom inquiry activities in this video on demand, produced by Annenberg. She has been trying to develop multi-sensory approaches to learning science to help a diversity of students, including ESL, inclusion students and other special needs students. Jean talks about classroom management and organization for messy lab activities and the benefits of cooperative learning. The video shows how an inclusion teacher can be used in this lesson.

Select Video 10, *Linda–Grades 2-4*, to see a resource teacher who models **inquiry-based science lessons** for teachers in her large urban district. Although not all of the content is directly aligned to this content statement, the strategies could be applied to any content.

BACK TO INDEX
BACK TO K-8 INDEX

# Grade 4

## INTRODUCTION TO CONTENT STATEMENTS

### GRADE BAND THEME: INTERCONNECTIONS WITHIN SYSTEMS

This theme focuses on helping students recognize the components of various systems and then investigate dynamic and sustainable relationships within systems using scientific inquiry.

### SCIENCE INQUIRY AND APPLICATION

During the years of PreK-4, all students must become proficient in the use of the following scientific processes, with appropriate **laboratory safety techniques**, to construct their knowledge and understanding in all science content areas:

- Observe and ask questions about the natural environment;
- Plan and conduct **simple investigations**;
- Employ simple equipment and tools to gather data and extend the senses;
- Use appropriate mathematics with data to construct reasonable explanations;
- Communicate about observations, investigations and explanations; and
- Review and ask questions about the observations and explanations of others.

### STRANDS

**Strand Connections:** Heat and electrical energy are forms of energy that can be transferred from one location to another. Matter has properties that allow the transfer of heat and electrical energy. Heating and cooling affect the weathering of Earth's surface and Earth's past environments. The processes that shape Earth's surface and the fossil evidence found can help decode Earth's history.

| EARTH AND SPACE SCIENCE (ESS) | PHYSICAL SCIENCE (PS) | LIFE SCIENCE (LS) |
|---|---|---|
| **Topic: Earth's Surface** | **Topic: Electricity, Heat and Matter** | **Topic: Earth's Living History** |
| This topic focuses on the variety of processes that shape and reshape Earth's surface. | This topic focuses on the conservation of matter and the processes of energy transfer and transformation, especially as they relate to heat and electrical energy. | This topic focuses on using fossil evidence and living organisms to observe that suitable habitats depend upon a combination of biotic and abiotic factors. |
| **CONDENSED CONTENT STATEMENTS** | | |
| • Earth's surface has specific characteristics and landforms that can be identified.<br>• The surface of Earth changes due to weathering.<br>• The surface of Earth changes due to erosion and deposition. | • The total amount of matter is conserved when it undergoes a change.<br>• Energy can be transformed from one form to another or can be transferred from one location to another. | • Changes in an organism's environment are sometimes beneficial to its survival and sometimes harmful.<br>• Fossils can be compared to one another and to present day organisms according to their similarities and differences. |

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 4

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Earth's Surface**

This topic focuses on the variety of processes that shape and reshape Earth's surface.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Surface of Earth**

**PreK-2:** Wind and precipitation can be measured, water can change state, heating and freezing can change the properties of materials, and living things can cause changes on Earth.

**Grade 3:** The composition and characteristics of rocks and soil are studied.

**Grade 4 Concepts**

Earth is known as the Blue Planet because about 70 percent of Earth's surface is covered in water. Freshwater is a small percentage of the overall water found on Earth; the majority is oceanic.

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 landforms 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 photos of an erosion event such as flooding).

**Future Application of Concepts**

**Grade 5:** Earth is a planet in the solar system that has a unique composition. Global seasonal changes are introduced, including monsoons and rainy seasons, which can change erosion and deposition patterns.

**Grades 6-8:** Changes in the surface of Earth are examined using data from the rock record and through the understanding of plate tectonics and the interior of Earth. Historical studies of erosion and deposition patterns are introduced, in addition to soil conservation, the interaction of Earth's spheres and ocean features specific to erosion and deposition.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| 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. | Plan, build and use a model (such as a small-scale stream table) that can demonstrate the formation of a landform or feature that formed through contact with water (alluvial fan, sinkhole, mid-channel bar, canyon, valley, depositional islands). Ask: ***What factors accelerate the processes? What factors must exist for the landform to form?*** Share findings with the class. | Using topographic or aerial maps, locate areas that have been formed through deposition and erosion.<br>Include areas of Ohio that have been impacted by glacial ice or movement. Discuss findings with the class. | Recognize that 70 percent of Earth's surface is water, which is why Earth is known as the Blue Planet.<br>Identify common landforms from maps or graphics. |
| | | Using LANDSAT data, research and locate a specific major landform or geographical feature on Earth that formed through erosion or deposition. Represent findings graphically or orally to the class. | Identify the processes that can change the surface of Earth (e.g., erosion, deposition, volcanic activity, earthquakes, glacial movement and/or weathering). |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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 photos of Earth's surface.
- The **NASA Visible Earth Program** houses hundreds of satellite photos 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, photos and graphics related to landforms and features that form through erosion and/or deposition.
- The **USGS** website 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.

## COMMON MISCONCEPTIONS

- NSTA offers a list of landform resources at **http://learningcenter.nsta.org/search.aspx?action=quicksearch&text=landforms**. Included are guides for formative assessment techniques that can be used to determine student misconceptions about landform formation, weathering and erosion. One reference in particular (an assessment probe) can be found at **http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/9780873552554.22**. It deals with beach sand and applies to all Earth Science content at grade 4.
- Funded by the National Science Foundation, ***Beyond Penguins and Polar Bears*** is an online magazine for K-5 teachers. For a list of common misconceptions about glacial movement, weathering and erosion, as well as ways to address them, visit **http://beyondpenguins.nsdl.org/issue/column.php?date=August2009&departmentid=professional&columnid=professional!misconceptions**.

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study ***Linda–Grades 2-4*** is an example of how to work with teacher teams to help students of all ability levels to develop scientifically accurate ideas and investigations.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 4

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Earth's Surface**

This topic focuses on the variety of processes that shape and reshape Earth's surface.

### 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.

**Note: The ice movement (above) refers to large bodies of ice, such as glaciers that can break large rocks into small ones.**

### CONTENT ELABORATION

**Prior Concepts Related to Weathering**

**PreK-2:** Wind is moving air, water and wind have measurable properties, water changes state, properties of materials change when exposed to various conditions (e.g., heating, freezing) and living organisms interact with their environment.

**Grade 3:** Rocks and soil have unique characteristics. Soil contains pieces of rock.

**Grade 4 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 simulations, laboratory testing and field observations.

**Future Application of Concepts**

**Grade 5:** Earth is a planet in the solar system that has a unique composition, global seasonal changes and patterns are introduced, including temperature fluctuations/ranges, monsoons and/or rainy seasons which can impact the weathering of Earth's surface.

**Grades 6-8:** The relationship between the characteristics of rocks and the environment in which they form is explored as well as how rocks break down (weather) and are transported (erosion), water flows through rock and soil at different rates, and the causes of changes on Earth's surface.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| 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. | Plan and implement an experiment to model and compare different types of weathering and/or rates of weathering that can occur. | Differentiate between weathering and erosion. | Identify weathering as processes that change rock at or near Earth's surface.<br>Recognize that weathering can occur at different rates. |
| | | Using geologic, topographic or aerial maps, research areas in the U.S. that are impacted by natural sinkholes, caverns or caves. Collect data regarding the characteristics of these regions. Compare and contrast the data to determine common characteristics that are present in each area. Represent findings graphically. | Recognize that water, wind, pollution/ gases in the air, ice movement, earthquakes, volcanoes, freezing/ thawing and plant action can all weather rock and soil. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- It is important 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).

## COMMON MISCONCEPTIONS

- Funded by the National Science Foundation, *Beyond Penguins and Polar Bears* is an online magazine for K-5 teachers. For a list of common misconceptions about glacial movement, weathering and erosion, as well as ways to address them, visit **http://beyondpenguins.nsdl.org/issue/column.php?date=August2009&departmentid=professional&columnid=professional!misconceptions**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study *Linda–Grades 2-4* is an example of how to work with teacher teams to help students of all ability levels to develop scientifically accurate ideas and investigations.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

MODEL CURRICULUM GRADE 4

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Earth's Surface**

This topic focuses on the variety of processes that shape and reshape Earth's surface.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Erosion and Deposition**

**PreK-2:** Wind is moving air, water and wind have measurable properties, water changes state, forces change the motion of an object and some forces act without touching (e.g., gravitational forces).

**Grade 3:** Soil and rock have unique characteristics. Soil and rock are nonliving resources that can be conserved.

**Grade 4 Concepts**

Erosion is a process that transports rock, soil or sediment to a different location. Weathering is the breakdown of large rock into smaller pieces of rock. Erosion is what carries the weathered material to a new location. Gravity plays an important role in understanding erosion, especially catastrophic events like mass wasting (e.g., mudslides, avalanches, landslides) or flooding.

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.

**Future Application of Concepts**

**Grade 5:** Earth is a planet in the solar system that has a unique composition, global seasonal changes are introduced, including monsoons and rainy seasons, which can change erosion and deposition patterns.

**Grades 6-8:** Historical studies of erosional and depositional patterns are introduced, in addition to soil conservation, the interaction of Earth's spheres, ocean features specific to erosion and deposition, and plate tectonics.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Sediment fences are often placed around construction sites to help control sediment from moving offsite (erosion) into the surrounding environment (deposition). Design and construct a model of one specific sediment-control measure (using scientific research). Evaluate and test it using different types of materials. Different groups in the class should model different methods of control.<br><br>Each group should present findings and demonstrate the models. | 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?***<br><br>Use the research data to make a geologic cross section (3-D or virtual model or a graphic) to model the canyon. | Differentiate between weathering and erosion. | Identify erosion as a process that transports rock, soil or sediment to a new location. |
| | Using a surficial geology map of Ohio, trace the patterns of glacial movement that can be recognized by a variety of glacial deposits or erosion. Build a model to investigate the movement of glacial ice that creates a similar pattern. Ask: ***What factors must exist to support the movement of glaciers? Why is glacial movement erosional and depositional?*** | Compare and contrast erosion and deposition. | Identify deposition as the settling or coming to rest of transported rock, soil or sediment. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The **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 website 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.

## COMMON MISCONCEPTIONS

- Funded by the National Science Foundation, *Beyond Penguins and Polar Bears* is an online magazine for K-5 teachers. For a list of common misconceptions about glacial movement, weathering and erosion, as well as ways to address them, visit **http://beyondpenguins.nsdl.org/issue/column.php?date=August2009&departmentid=professional&columnid=professional!misconceptions**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study *Linda–Grades 2-4* is an example of how to work with teacher teams to help students of all ability levels to develop scientifically accurate ideas and investigations.

The Annenberg Foundation offers training modules that support Earth and Space Sciences for K-4 teachers. There are numerous resources and video clips of actual classroom practices that can be useful training tools at **http://www.learner.org/resources/series195.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 4

## LIFE SCIENCE (LS)

**Topic: Earth's Living History**

This topic focuses on using fossil evidence and living organisms to observe that suitable habitats depend upon a combination of biotic and abiotic factors.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Behavior, Growth and Changes**

**PreK-2:** Plants and animals have variations in their physical traits that enable them to survive in a particular environment. Living things that once lived on Earth no longer exist, as their needs were not met. Living things have basic needs, which are met by obtaining materials from the physical environment.

**Grade 3:** Plants and animals have life cycles that are part of their adaptations for survival in their natural environments.

**Grade 4 Concepts**

Ecosystems are based on interrelationships among and between biotic and abiotic factors. Ohio has experienced various weather patterns. Some parts of Ohio hosted glaciers and other parts of Ohio were submerged with water. Ecosystems can change rapidly (e.g., volcanoes, earthquakes, or fire) or very slowly (e.g., climate change). Major changes over a short period of time can have a significant impact on the ecosystem and the populations of plants and animals living there. The changes that occur in the plant and animal populations can impact access to resources for the remaining organisms, which may result in migration or death. The fossil record provides evidence for changes in populations of species.

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.

**Note: Grade 4 ES focuses on changes to Earth's surface due to erosion, deposition of soil, rock sediment, flooding, volcanoes and earthquakes that can be taught along with this content.**

**Future Application of Concepts**

**Grades 6-8:** Organisms that survive pass on their traits to future generations. Climate, rock record and geologic periods are explored in Earth and Space Science.

**High School:** The concepts of evolution are explored.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| 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. | Conduct an investigation to determine if removing or adding plants to an area increases or decreases erosion. Ask: *How does this impact other organisms in that environment?* | Read a firsthand description, view drawings of Ohio ecosystems as first observed by explorers and compare the historical environmental descriptions to the current environment. Explain the changes that occurred in the biotic and abiotic components of the ecosystem. | Describe the immediate 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/education/teachers-corner/library/life-returns01.shtml#01**. | Describe major changes in Ohio's environments over time and the organisms supported in each (e.g., oceanic, glacial, wetlands, forests). |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Investigate various species that have been endangered due to environmental changes and examine efforts to reestablish and support their populations. One example is the trumpeter swan. The **Ohio History Central** provides details of this bird's story.
- The **Virtual Nature Trail at Penn State New Kensington** is an opportunity to observe photos 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.
- The ODNR-Division of Wildlife's **Research and Survey** website has information on current research projects on Ohio wildlife, including migration tracking, distribution and reintroduction and monitoring programs.
- The ODNR-Division of Wildlife has a poster with an activity called *Ohio's Wildlife History*. The poster can be ordered by mail through the Education Materials Brochure found online at **www.wildohio.com**.
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In the activity *Oh Deer*, students portray deer and habitat components in a physical activity that illustrates the factors that cause fluctuations in wildlife populations over time. In *Here Today, Gone Tomorrow*, students identify and describe causes of extinction within animal species and identify locally endangered and threatened species.

### Career Connection

Students will choose a recent disaster to explore (e.g., hurricane, earthquake, oil spill, tsunami) and identify the immediate and long-term consequences including the interactions and relationships among the Earth's surface, ecosystem, and plant and animal populations. Through exploring the impact, students will address the types of careers involved in addressing the issues. This may include performing tasks, such as relocating organisms, rebuilding habitats, rescuing or rehabilitating organisms.

## COMMON MISCONCEPTIONS

- Students may think that people provide the materials (water, nutrients, light) needed for plants to survive. **Beyond Penguins and Polar Bears** is an online magazine for K-5 teachers that provides information for misconceptions about plants.
- A list of common **ecological misconceptions** about adaptation is provided with strategies for implementing the 5E model of instruction to overcome misconception.

## DIVERSE LEARNERS

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

- Many *Project Wild* activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. In the activity *Oh Deer*, students portray deer and habitat components in a physical activity that illustrates the factors that cause fluctuations in wildlife populations over time. In *Here Today, Gone Tomorrow*, students identify and describe causes of extinction within animal species and identify locally endangered and threatened species.

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

Session 5 of the Annenberg Media series ***Essential Science for Teachers: Life Science*** provides information about how children can learn about the variations of living things and offers with classroom footage to illustrate implementation at **http://www.learner.org/resources/series179.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 4

## LIFE SCIENCE (LS)

**Topic: Earth's Living History**

This topic focuses on using fossil evidence and living organisms to observe that suitable habitats depend upon a combination of biotic and abiotic factors.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Behavior, Growth and Changes**

**PreK-2:** Plants and animals have variations in their physical traits that enable them to survive in a particular environment. Living things that once lived on Earth no longer exist, as their needs were not met. Living things have basic needs, which are met by obtaining materials from the physical environment.

**Grade 3:** Plants and animals have life cycles that are part of their adaptations for survival in their natural environments.

**Grade 4 Concepts**

Fossils provide evidence that many plant and animal species are extinct and that many species have changed over time. The types of fossils that are present provide evidence about the nature of the environment at that time. As the environment changed so did the types of organisms that could survive in that environment.

The opportunity to learn about an increasing variety of living organisms, both the familiar and the exotic, should be provided. The observations and descriptions of organisms should become more precise in identifying similarities and differences based upon observed structures. Emphasis can still be on external features; however, finer detail than before should be included. Hand lenses and microscopes should be routinely used. Microscopes are used not to study cell structure but to begin exploring the world of organisms that cannot be seen by the unaided eye. Non-Linnaean classification systems should be developed that focus on gross anatomy, behavior patterns, habitats and other features.

**Future Application of Concepts**

**Grades 6-8:** Diversity of species will be explored in greater detail. The study of Modern Cell Theory and rock formation is required (Earth and Space Science).

**High School:** The concepts of evolution and cell biology are explored.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Propose and test multiple ways that living things with soft body parts can leave fossil evidence. | Experiment with making fossils to determine some of the necessary (living and nonliving) conditions for making fossils and to determine if similar conditions exist today. Materials used should include clay, dough, sand, mud, etc. Conditions should include moist, wet and dry. Representations of living organisms used should include those with hard body parts (exoskeletons, bones) and those with soft body parts (plants). | 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/subcategory_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/education/explorations/tours/intro/Introkto4b/tour1nav.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**. | |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The University of Berkeley website **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**.

## COMMON MISCONCEPTIONS

- The Annenberg Media series *Essential Science for Teachers:* **Life Science: Session 5**: *Children's Ideas* provides greater insight to misconceptions children hold about differing traits within a species and their causes. Strategies to address those misconceptions are addressed.
- Students may have the **naïve conception** that if organisms look alike, then they must have a common evolutionary history.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

Session 5 of the Annenberg Media series *Essential Science for Teachers: Life Science* provides information about how children can learn about the variations of living things and offers classroom footage to illustrate implementation at **http://www.learner.org/resources/series179.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 4

## PHYSICAL SCIENCE (PS)

**Topic: Electricity, Heat and Matter**

This topic focuses on the conservation of matter and the processes of energy transfer and transformation, especially as they apply to heat and electrical energy.

### 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.

**Note 1: At this grade, the discussion of conservation of matter should be limited to a macroscopic, observable level.**

**Note 2: States of matter are found in PS grade 3. Heating and cooling is one way to change the state of matter.**

### CONTENT ELABORATION

**Prior Concepts Related to Changes of Matter**

**PreK-2:** Simple measuring instruments are used to observe and compare properties of objects. Changes in objects are investigated.

**Grade 3:** Objects are composed of matter, which has weight mass* and takes up space. Matter includes solids, liquids and gases (air). Phase changes are explored.

**Grade 4 Concepts:**

Some properties of objects may stay the same even when other properties change. For example, water can change from a liquid to a solid, but the mass* of the water remains the same. Parts of an object or material may be assembled in different configurations, but the mass* remains the same. The sum of all of the parts in an object equals the mass* of the object.

When a solid is dissolved in a liquid, the mass* of the mixture is equal to the sum of the masses* of the liquid and solid.

At this grade level, the discussion of conservation of matter should be limited to a macroscopic, observable level. Conservation of matter must be developed from experimental evidence collected in the classroom. After the concept has been well established with experimental data and evidence, investigations can include interactions that are more complex where the mass* may not appear to stay constant (e.g., fizzing tablets in water).

**Note: Mass* is an additive property of objects and volume is usually an additive property for the same material at the same conditions. However, volume is not always an additive property, especially if different substances are involved. For example, mixing alcohol with water results in a volume that is significantly less than the sum of the volumes.**

**Future Application of Concepts**

**Grades 6-8:** Conservation of matter in phase changes and chemical reactions is explained by the number and type of atoms remaining constant. The idea of conservation of energy is introduced.

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Evaluate research data providing information about the decomposition time for paper, glass, plastic and aluminum. Propose a sustainable plan that might be adopted by a larger population of citizens for minimizing waste products and reserving more space in our landfills. Develop a presentation that could be for an outside audience with the authority to implement the plan within a community. | Investigate what happens to the total amount of mass* during many types of changes (e.g., ice melting, salt dissolving, paper tearing, candle burning, Alka-Seltzer® in water).<br><br>Propose reasons for any difference in the final weight (mass). Design a revised experiment to test proposals. <br><br>*While mass is the scientifically correct term to use in this context, the **NAEP 2009 Science Framework** (page 27) recommends using the more familiar term "weight" in the elementary grades with the distinction between mass and weight being introduced at the middle school level. In Ohio, students will not be assessed on the differences between mass and weight until Grade 6. | Explain why the volume of water decreases when placed in an open container and left to sit for an extended period of time. | Recognize that the amount of matter stays constant during any change. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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.
- **Essential Science for Teachers: Physical Science Video 3 Conservation of Matter Part I**, a video on demand produced by Annenberg, is designed for teachers to improve their understanding of physical science and make them aware of common student misconceptions. It also highlights ways to help students overcome misconceptions. While teachers should be aware of the ideas of physical changes and the particle nature of matter, these topics are not appropriate for this grade level.
- **Essential Science for Teachers: Physical Science Video 3 Conservation of Matter Part II**, a video on demand produced by Annenberg, is designed for teachers to improve their understanding of physical science, to make them aware of common student misconceptions. It also highlights ways to help students overcome these misconceptions. While teachers should be aware of the ideas of chemical changes and the particle nature of matter, these topics are not appropriate for this grade level.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- **Gases are** not matter because most are invisible.
- Gases do not have mass*.
- **When things dissolve**, they disappear.
- Melting and dissolving are confused.
- Mass* and volume, which both describe an amount of matter, are the same property.
- Breaking something or dissolving makes it weigh less.
- Changing the shape changes the mass* and volume.
- Students believe matter is lost during burning.
- Students believe that a warmed gas weighs less than the same gas that is cooler (Driver, Squires, Rushworth & Wood-Robinson, 1994).

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

From times of 3:45 to about 13:55 and from 15:00 to 22:20 on this segment of **Essential Science for Teachers: Physical Science** produced by Annenberg, see how to lead students through questions and experiences that allow them to build their ideas of conservation of matter. Please note that exploring the differences between weight and mass and using the particle model of matter to explain conservation of matter are not appropriate for this grade.

*Case Studies in Education* is a series of videos on demand produced by Annenberg. The segment titled **Linda–Grades 2-4** features a resource teacher who models inquiry-based science lessons for teachers in her large urban district. The segment titled **Terez–Grade 4** features a teacher who is working to incorporate portfolios in her science teaching. Although not all of the content is directly aligned to this content statement, the strategies could be applied to any content.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 4

## PHYSICAL SCIENCE (PS)

**Topic: Electricity, Heat and Matter**

This topic focuses on the conservation of matter and the processes of energy transfer and transformation, especially as they apply to heat and electrical energy.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Heat and Electricity**

**PreK-2:** Temperature is a property of objects. Sunlight affects the warming or cooling of air, water and land (ESS). Charged objects can attract uncharged objects and may either attract or repel other charged objects. Magnetic objects can attract things made of iron and may either attract or repel other magnetic objects.

**Grade 3:** Objects that have energy can cause change. Heat, electrical energy, light, sound and magnetic energy are all forms of energy.

**Grade 4 Concepts:**

The addition of heat may increase the temperature of an object. The removal of heat may decrease the temperature of an object. There are materials in which the entire object becomes hot when one part of the object is heated (e.g., in a metal pan, heat flows through the pan on the stove transferring the heat from the burner outside the pan to the food in the pan). There are other objects in which parts of the object remain cool even when another part of the object is heated (e.g., in a Styrofoam® cup, very little of the warmth from hot liquid inside the cup is transferred to the hand holding the cup).

Electrical conductors are materials through which electricity can flow easily. Electricity introduced to one part of the object spreads to other parts of the object (e.g., copper wire is an electrical conductor because electricity flows through the wires in a lamp from the outlet to the light bulb and back to the outlet).

Electrical insulators are materials through which electricity cannot flow easily. Electricity introduced to one part of the object does not spread to other parts of the object (e.g., rubber surrounding a copper wire is an electrical insulator because electricity does not flow through the rubber to the hand holding it).

Electrical conductivity must be explored through testing common materials to determine their conductive properties.

In order for electricity to flow through a circuit, there must be a complete loop through which the electricity can pass. When an electrical device (e.g., lamp, buzzer, motor) is not part of a complete loop, the device will not work. Electric circuits must be introduced in the laboratory by testing different combinations of electrical components. When an electrical device is a part of a complete loop, the electrical energy can be changed into light, sound, heat or magnetic energy. Electrical devices in a working circuit often get warmer.

BACK TO INDEX

BACK TO K-8 INDEX

When a magnet moves in relation to a coil of wire, electricity can flow through the coil. When a wire conducts electricity, the wire has magnetic properties and can push and/or pull magnets. The connections between electricity and magnetism must be explored in the laboratory through experimentation.

**Note 1: Exploring heat transfer in terms of moving submicroscopic particles is not appropriate at this grade level.**

**Note 2: The word "heat" is used loosely in everyday language, yet it has a very specific scientific meaning. Usually what is called heat is actually "thermal or radiant energy." An object has thermal energy due to the random movement of the particles that make up the object. Radiant energy is that which is given off by objects through space (e.g., warmth from a fire, solar energy from the sun). "Heating" is used to describe the transfer of thermal or radiant energy to another object or place. Differentiating between these concepts is inappropriate at this grade level. This document uses the same conventions as noted in the NAEP 2009 Science Framework (see page 29) where "heat" is used in lower grades. However, the word "heat" has been used with care so it refers to a transfer of thermal or radiant energy. The concept of thermal energy, as it relates to particle motion, is introduced in grade 6.**

**Note 3: Knowing the specifics of electromagnetism is not appropriate at this grade level. At this point, the connections between electricity and magnetism are kept strictly experiential and observational.**

**Note 4: Energy transfer (between objects or places) should not be confused with energy transformation from one form of energy to another (e.g., electrical energy to light energy).**

### Future Application of Concepts

**Grade 5:** Light and sound are explored further as forms of energy.

**Grades 6-8:** Thermal energy is related to the atomic theory. Kinetic and potential energy are two ways objects can store energy. Conservation of energy and energy transfer through radiation, convection and conduction, and the transfer of electrical energy in circuits are introduced.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Design a device involving energy transfers.** | | | |
| Design and construct a device that causes a small cart to roll and involves energy transfers between four objects (e.g., push a ball off a table so it falls on an object that releases a rubberband cart). | | Design and construct a device that causes a small cart to roll and involves energy transfers between four objects (e.g., push a ball off a table so it falls on an object that releases a rubberband cart). | Recognize that energy can cause motion or create change. |
| **Investigate a simple circuit.** | | | |
| Design and construct a switch that can turn a light on and off in a circuit. | Build a circuit that contains two light bulbs.<br>Analyze the differences between working and nonworking circuits and determine patterns and trends in the experimental evidence.<br>Formulate a conceptual model of a working circuit based upon the trends in the experimental evidence. | Pictorially represent ways to assemble the circuit and note which are able to light the bulbs and which are not.<br>Compare and contrast circuits that light the bulbs with circuits that do not light the bulbs.<br>Outline the functions of the components of a simple electric circuit (conductor, insulator, energy source, light bulb, switch).<br>Pictorially represent the flow of energy in a circuit in which a battery is used to light a bulb. | Recognize that a working circuit requires a continuous loop of electrical conductors. |

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate the transfer of heat energy.** | | | |
| | Plan and implement an experiment to investigate the energy transfer between hot (but not hot enough to burn) and cold water.<br><br>Formulate a conceptual model that can account for the trends observed in the results. | Organize and represent the data for easy interpretation.<br><br>Analyze the data to determine patterns and trends.<br><br>Explain the trends in the results using the conceptual model. | Measure the temperature of water.<br><br>Recognize that an increase in temperature indicates an increase in heat energy and a decrease in temperature indicates a decrease in heat energy. |
| | | Contrast electrical conductors and electrical insulators. | Identify ways the temperature of an object can be changed (e.g., rubbing, heating, bending of metal). |
| | | Contrast thermal conductors and thermal insulators. | Identify different types of energy conversions within an electrical circuit. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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. The optional sections that deal with adding bulbs and batteries are not aligned with this content statement.
- **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.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- Some items cannot be heated.
- Metals get hot easily because they "draw in heat."
- **Energy is a thing**, an object or something that is tangible.
- Cold can be transferred.
- **Larger magnets are** stronger than smaller magnets.
- Current flows from a battery (or other source of electricity) to a light bulb (or other item that consumes electricity), but not from the light bulb to the battery.
- Electricity is produced in the wall socket.
- Pure water is a good conductor of electricity.
- Electricity from a dry cell will shock or hurt if it is touched.
- All wires are insulated.
- Birds can perch on bare wires without being hurt because birds have insulated feet.
- A charge object can only affect other charged objects.
- **Ice cannot change temperature.**
- Heat is a substance.
- Heat is not energy.
- Temperature is a property of a particular material or object (metal is naturally colder than plastic).
- The temperature of an object depends on its size.
- Heat and cold are different, rather than being opposite ends of a continuum.
- Objects of different temperatures that are in constant contact with each other or in contact with air at a different temperature do not necessarily move toward the same temperature.
- Heat only travels upward.
- Heat rises.
- Objects that readily become warm (conductors of heat) do not readily become cold.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

**Tom**, a new fifth-grade teacher who works with many special needs students, is featured in this video on demand produced by Annenberg. Starting from a time of about 10:15, the video shows Tom working with his class to teach about electricity. Students construct Venn diagrams to compare motors and generators, then explore how different variables in an electromagnet (such as the number of coils) affect the effectiveness of the magnet. Tom has students generate concept maps for magnets. The beginning of the video, while not directly related to this content statement, shows Tom working to incorporate more formative assessment in his teaching and using strategies such as storyboards and concept mapping to reach his diverse learners. The strategies shown can be adapted to all science content.

**Linda**, a resource teacher who models inquiry-based science lessons for grades 2-4 teachers in her large urban district, is featured in this video on demand produced by Annenberg. Although not all of the content is directly aligned to this content statement, the strategies could be applied to any content.

**Terez**, a fourth-grade teacher who is working to incorporate portfolios in her science teaching, is featured in this video on demand produced by Annenberg. Although not all of the content is directly aligned to this content statement, the strategies could be applied to any content.

BACK TO INDEX
BACK TO K-8 INDEX

# Grade 5

## INTRODUCTION TO CONTENT STATEMENTS

### GRADE BAND THEME: INTERCONNECTIONS WITHIN SYSTEMS

This theme focuses on helping students recognize the components of various systems and then investigate dynamic and sustainable relationships within systems using scientific inquiry.

### SCIENCE INQUIRY AND APPLICATION

During the years of grades 5-8, all students must use the following scientific processes, with appropriate **laboratory safety techniques**, to construct their knowledge and understanding in all science content areas:

- Identify questions that can be answered through scientific investigations;
- Design and conduct a **scientific investigation**;
- Use appropriate mathematics, tools and techniques to gather data and information;
- Analyze and interpret data;
- Develop descriptions, models, explanations and predictions;
- Think critically and logically to connect evidence and explanations;
- Recognize and analyze alternative explanations and predictions; and
- Communicate scientific procedures and explanations.

### STRANDS

**Strand Connections:** Cycles on Earth, such as those occurring in ecosystems, in the solar system, and in the movement of light and sound result in describable patterns. Speed is a measurement of movement. Change in speed is related to force and mass*. The transfer of energy drives changes in systems, including ecosystems and physical systems.

| EARTH AND SPACE SCIENCE (ESS) | PHYSICAL SCIENCE (PS) | LIFE SCIENCE (LS) |
|---|---|---|
| **Topic: Cycles and Patterns in the Solar System** | **Topic: Light, Sound and Motion** | **Topic: Interactions within Ecosystems** |
| This topic focuses on the characteristics, cycles and patterns in the solar system and within the universe. | This topic focuses on the forces that affect motion. This includes the relationship between the change in speed of an object, the amount of force applied and the mass* of the object. Light and sound are explored as forms of energy that move in predictable ways, depending on the matter through which they move. | This topic focuses on foundational knowledge of the structures and functions of ecosystems. |
| **CONDENSED CONTENT STATEMENTS** | | |
| • The solar system includes the sun and all celestial bodies that orbit the sun. Each planet in the solar system has unique characteristics.<br>• The sun is one of many stars that exist in the universe.<br>• Most of the cycles and patterns of motion between the Earth and sun are predictable. | • The amount of change in movement of an object is based on the mass* of the object and the amount of force exerted.<br>• Light and sound are forms of energy that behave in predicable ways. | • Organisms perform a variety of roles in an ecosystem.<br>• All of the processes that take place within organisms require energy. |

BACK TO INDEX

BACK TO K-8 INDEX

MODEL CURRICULUM GRADE 5

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Cycles and Patterns in the Solar System**

This topic focuses on the characteristics, cycles and patterns in the solar system and within the universe.

### 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.

**Note: The shape of Earth's orbit is nearly circular (also true for other planets). Many graphics that illustrate the orbit overemphasize the elliptical shape, leading to the misconception regarding seasonal change being related to how close Earth is to the sun. The discussion of planet characteristics should be at an introductory level for this grade.**

### CONTENT ELABORATION

**Prior Concepts Related to Solar System**

**PreK-2:** The moon, sun and stars can be observed at different times of the day or night. The observable shape of the moon changes throughout the month, the sun's position in the sky changes in a single day and from day to day and the sun is the principal source of energy. Earth's atmosphere is discussed.

**Grades 3-4:** All objects are made of matter and light is a form of energy. Earth's surface is discussed and gravitational forces are introduced.

**Grade 5 Concepts**

Eight major planets in the solar system orbit the sun. Some of the planets have a moon or moons that orbit them. Earth is a planet that has a moon that orbits it. The planets orbits are because of their gravitational attraction to the sun. Moons orbit around planets because of their gravitational attraction to the planets.

Asteroids are metallic, rocky bodies that orbit the sun but are too small to be classified as a planet. A meteor appears when a particle or chunk of metallic or stony matter called a meteoroid enters Earth's atmosphere from outer space. Comets are a mixture of ices (both water and frozen gases) that are not part of a planet. Pluto is classified as a dwarf planet (definition from http://www.nasa.gov).

General information regarding planetary positions, orbital patterns, planetary composition and recent discoveries and projects (e.g., missions to Mars) are included in this content. Tools and technology are an essential part of understanding the workings within the solar system.

**Note: Additional information about gravity is found in PS grade 5.**

**Future Application of Concepts**

**Grades 6-8:** The interior and exterior composition of Earth, Earth's unique atmosphere, light waves, electromagnetic waves, interactions between the Earth, moon and sun, and gravitational forces are explored in more depth.

**High School:** Galaxies, stars and the universe are studied in the physical sciences.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Choose a planet (other than Earth) and research and develop a plan to colonize the planet with humans. Evaluate current conditions and what would be needed to meet the basic requirements for humans to live on Mars.<br><br>Critique the plan. Ask: I*s the plan feasible? What equipment is required?*<br><br>Make a final recommendation based on the research. Present recommendations to the class.<br><br> | Choose a major planet. Plan and build a scaled model that can demonstrate the planet size and rotation orbit in relationship to the sun and the Earth. Conduct the demonstration (with explanation) to the class.<br><br> | Make a table, chart or graphic that interprets the general characteristics of the major planets in the solar system. Use real data (current) to compare and contrast the findings. | Recognize that there are eight major planets in the solar system and they all orbit the sun.<br><br>Recognize that other celestial bodies also orbit the sun. These can include dwarf planets, comets, asteroids, meteoroids and comets. |
| | | Research the history of the exploration of the solar system or a recent space discovery. Make a timeline or write a report to interpret and clarify the major events, the tools and technology used, and the discoveries made. Share findings with the class.<br><br> | Identify a telescope as a tool that can be used to magnify the appearance of objects in the solar system.<br><br> |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Ensuring that relevant and up-to-date information about the solar system is important. **NASA's** website 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.
- It is important to incorporate inquiry and student investigation into learning about the solar system. Researching the existing conditions on different planets or in space and comparing them to the conditions that support life on Earth can help in understanding the history of Earth and the solar system. **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 website.

## COMMON MISCONCEPTIONS

- *Margarita–Grades 5-8* is a case study that outlines different ways of approaching science for ESL students (see below), available at **http://www.learner.org/resources/series21.html**.
- NASA lists common misconceptions for all ages about the sun and the Earth at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- For examples of misconceptions that elementary students may have about the solar system and space (astronomy), and resources to address misconceptions through investigation, visit **http://amasci.com/miscon/opphys.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies *Sarah–Grade 5, Tom–Grade 5*, and *Erien, Year One–Grade 5* provide examples of developing meaningful science assessments, learning core science concepts and using effective questioning techniques for scientific inquiry.

BACK TO INDEX

BACK TO K-8 INDEX

MODEL CURRICULUM GRADE 5

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Cycles and Patterns in the Solar System**

This topic focuses on the characteristics, cycles and patterns in the solar system and within the universe.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Sun**

**PreK-2:** The sun can be observed at different times of the day or night. The sun's position in the sky changes in a single day and from day to day. The sun is the principal source of energy.

**Grades 3-4:** All objects are made of matter. Heat and light are forms of energy. Gravitational forces are introduced.

**Grade 5 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. Stars appear in patterns called constellations, which can be used for navigation. Because they are so far away, they do not appear as large as the sun.

General facts about the size and composition of the sun are introduced. Details (e.g., age of the sun, specific composition, temperature values) are above grade level. The emphasis should be on general characteristics of stars and beginning to understand the size and distance of the sun in relationship to the Earth and other planets.

Current and new discoveries related to stars and the sun must be included.

**Future Application of Concepts**

**Grades 6-8:** Earth's unique atmosphere, light waves, electromagnetic waves, interactions between the Earth, moon and sun (including the phases of the moon and tides), and gravitational forces are explored in more depth.

**High School:** Galaxies, stars and the universe are studied in the Physical Sciences.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Solar energy collection is most effective in areas that receive direct sunlight for long periods of time. Research areas on Earth that receive direct sunlight (can use information and data from the model suggested for Demonstrating Science Knowledge). Critique different zones of the Earth. Evaluate the data and make a recommendation (using the scientific data) to locate a solar energy facility. Share and defend the recommendation with the class. | Choose a major planet. Plan and build a scaled model that can demonstrate the planet size and rotation orbit in relationship to the sun and the Earth. Conduct the demonstration (with explanation) to the class. | Differentiate between the sun and a red dwarf or blue giant star. Make a table or chart to represent the comparison. | Identify the sun as a medium-sized star and the only star in the solar system. |
| | | | Recall that there are many other stars in the universe and they are different sizes, but the sun appears larger because it is closer to the Earth. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **NASA** provides background data about the sun (including recent discoveries, research and photos) 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.

## COMMON MISCONCEPTIONS

- NASA lists common misconceptions for all ages about the sun and the Earth at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- For examples of misconceptions that elementary students may have about the solar system and space (astronomy), and resources to address misconceptions through investigation, visit **http://amasci.com/miscon/opphys.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies *Sarah–Grade 5, Tom–Grade 5,* and *Erien, Year One–Grade 5* provide examples of developing meaningful science assessments, learning core science concepts and using effective questioning techniques for scientific inquiry.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 5

# EARTH AND SPACE SCIENCE (ESS)

**Topic: Cycles and Patterns in the Solar System**

This topic focuses on the characteristics, cycles and patterns in the solar system and within the universe.

### 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.

**Note 1: The amount of direct sunlight that Earth receives is related to the altitude of the sun, which affects the angle of the sun's rays, and the amount of time the sun is above the horizon each day.**

**Note 2: Different regions around the world have seasonal changes that are not based solely on average temperature (e.g., rainy season, dry season, monsoon season).**

### CONTENT ELABORATION

**Prior Concepts Related to Earth, Sun and Moon**

**PreK-2:** The sun and moon can be observed at different times of the day or night. The sun's position in the sky changes in a single day and from day to day. The observable shape of the moon changes throughout the month. The sun is the principal source of energy.

**Grades 3-4:** All objects are made of matter. Heat and light are forms of energy. Gravitational forces are introduced.

**Grade 5 Concepts**

Models, interactive websites 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.

Seasonal change should be expanded in grade 5 to include regions of the world that experience specific seasonal weather patterns and natural weather hazards (e.g., hurricane season, monsoon season, rainy season, dry season). This builds upon making observations of the seasons throughout the school year in the earlier grades and prepares students for understanding the difference between weather and climate.

**Future Application of Concepts**

**Grades 6-8:** Earth's unique atmosphere, light waves, electromagnetic waves, interactions between the Earth, moon and sun (including the phases of the moon and tides), climate studies, and gravitational forces are explored in more depth.

**High School:** Galaxies, stars and the universe are studied in the Physical Sciences.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Solar energy collection is most effective in areas that receive direct sunlight for long periods of time. Research specific locations on Earth that receive direct sunlight. Evaluate the data and make a recommendation (using the scientific data) to locate a solar energy facility. Share and defend the recommendation with the class. | Using a simple model, investigate the positions of the sun, moon and Earth to detect and test the reasons why the moon and sun appear to change position in the sky and the phases of the moon. **Note: The names of the phases are not the emphasis at this grade level. The emphasis is on observational differences. Names of phases are found in grade 7.** | Represent the sun, moon and Earth and their orbits graphically and to scale. Use actual data and measurements for the representation. | Recognize that the rotation of Earth on its axis produces day and night, which is why the sun, stars and moon appear to change position in the sky. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **The 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.

## COMMON MISCONCEPTIONS

- *Beyond Penguins* and Polar Bears is an online magazine for K-5 teachers. Misconceptions about why there are seasons are common at this age (e.g., the Earth is closer to the sun in the summer and that is why it is so hot). For a list of common misconceptions and ways to address them, visit **http://beyondpenguins.nsdl.org/issue/column.php?date=May2008&departmentid=professional&columnid=professional!science&test**.
- NASA lists common misconceptions for all ages about the sun and the Earth at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- For examples of misconceptions that elementary students may have about the solar system and space (astronomy), and resources to address misconceptions through investigation, visit **http://amasci.com/miscon/opphys.html**.

BACK TO INDEX

BACK TO K-8 INDEX

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies ***Sarah–Grade 5, Tom–Grade 5,*** and ***Erien, Year One–Grade 5*** provide examples of developing meaningful science assessments, learning core science concepts and using effective questioning techniques for scientific inquiry.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 5

## LIFE SCIENCE (LS)

**Topic: Interconnections within Ecosystems**

This topic focuses on foundational knowledge of the structures and functions of ecosystems.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Behavior, Growth and Changes**

**PreK-2:** Plants get energy from sunlight. Animals get energy from plants and other animals. Living things cause changes on Earth.

**Grade 5 Concepts**

The content statements for fifth-grade life science are each partial components of a larger concept. The parts have been isolated to call attention to the depth of knowledge required to build to one of biology's foundational theories: dynamic relationships within ecosystems. It is recommended that the content statements be combined and taught as a whole. For example, it is important that the ecological role of organisms is interwoven with a clear understanding that all living things require energy.

Plants and some microorganisms are producers. They are the foundation of the food web. Producers transform energy from the sun and make food through a process called photosynthesis. Animals get their energy by eating plants and other animals that eat plants. Animals are consumers and many form predator-prey relationships. Decomposers (primarily bacteria and fungi) are consumers that use waste materials and dead organisms for food. Decomposers also return nutrients to the ecosystem.

One way ecosystem populations interact is centered on relationships for obtaining energy. Food webs are defined in many ways, including as a scheme of feeding relationships, which resemble a web. This web serves as a model for feeding relationships of member species within a biological community. Members of a species may occupy different positions during their lives. Food chains and webs are schematic representations of real-world interactions. For this grade level, it is enough to recognize that food webs represent an intertwining of food chains within the same biological community. See the next content statement for details on grade-appropriate food webs.

Organisms have symbiotic relationships in which individuals of one species are dependent upon individuals of another species for survival. Symbiotic relationships can be categorized as mutualism where both species benefit, commensalism where one species benefits and the other is unaffected, and parasitism where one species benefits and the other is harmed.

Investigations of locally threatened or endangered species must be conducted and include considerations of the effects of remediation programs, species loss and the introduction of new species on the local environment.

**Note: At this grade, species can be defined by using Ernst Mayer's definition "groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups." Assessments will not include the definition of species.**

**Future Application of Concepts**

**Grades 6-8:** The importance of biodiversity within an ecosystem is explored.

**High School:** The concepts of evolution and biodiversity are explored.

BACK TO INDEX

BACK TO K-8 INDEX

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design and build a self-sustaining ecosystem (e.g., terrarium, bottle biology). Considerations for the ecosystem include the size of the container, the location to create the proper temperature, light and humidity, and organisms that will support one another. | Investigate change in an established model of an ecosystem over time (e.g., terrarium, aquarium). Answer: *What would happen with removal or introduction of one kind of living thing (e.g., one species of producers not all producers)?*<br><br>Design experiments to observe what actually happens when one species is changed.<br><br>**Note: At this grade, species can be defined by using Ernst Mayer's definition of "groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups." Students will not be assessed on the definition of species at this grade level.** | Compare the roles of producers, consumers and decomposers and explain how they work together within an ecosystem. | Given a list of organisms and a description of their interactions within an environment, classify them as producers, consumers, decomposers or by type of symbiotic relationships (mutualism, commensalism and parasitism). |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Conduct a field study involving a hands-on investigation of a rotting log in a temperate forest. Examine the relationships among organisms (e.g., decomposers, green plants, insects, worms) found in the soil.
- Based on observations of the local environment, build a food web describing each organism's role and impact within the food web.
- 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.
- ODNR-Division of Wildlife's **A to Z Species Guide** has photos, information, tracks and sounds of Ohio's wild animals. The guide also includes the diet of organisms.
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. The following activites are helpful in teaching this content. *Quick Frozen Critters*—Through a game of freeze tag, students will become part of a predator/prey interaction. *What's for Dinner*—Students list and analyze sources of food to illustrate that all animals, including people, depend on plants as a food source. *Surprise Terrarium*—students create a classroom terrarium to illustrate animal behavior. *Good Buddies*—students research pairs of animals, play a card game, and classify the pairs of animals according to the three major forms of symbiotic relationships. *Designing a Habitat* (Aquatic WILD)—Students design a habitat suitable for aquatic wildlife to survive.

### Career Connection

When examining factors that impact white-tailed deer population in Ohio, students will determine the implications for a community when the population decreases or increases. After students determine the implications for a community, students will identify careers directly or indirectly impacted in addressing the issues. This conversation will offer an opportunity to discuss how ecosystems can impact an economy. Environmental circumstances dictate demands and influence the necessity of certain careers.

## COMMON MISCONCEPTIONS

- The Annenberg Media series **Essential Science for Teachers** can be used to provide greater insight to misconceptions children hold about living things and energy. Classroom videos and lessons are provided to help students avoid these misconceptions.
- **AAAS' Benchmarks 2061 Online, Chapter 15**, 5e, *Flow of Matter and Energy*, Plant and Animal Nutrition, outlines children's misconceptions about energy in relationship to producers and consumers.

## DIVERSE LEARNERS

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

- Many *Project Wild* activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. *Quick Frozen Critters*—Through a game of freeze tag, students will become part of a predator/prey interaction. *What's for Dinner*—Students list and analyze sources of food to illustrate that all animals, including people, depend on plants as a food source. *Surprise Terrarium*—students create a classroom terrarium to illustrate animal behavior. *Good Buddies*—students research pairs of animals, play a card game, and classify the pairs of animals according to the three major forms of symbiotic relationships. *Designing a Habitat* (Aquatic WILD)—Students design a habitat suitable for aquatic wildlife to survive.

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies ***Sarah–Grade 5, Tom–Grade 5,*** and ***Erien, Year One–Grade 5*** provide examples of developing meaningful science assessments, learning core science concepts and using effective questioning techniques for scientific inquiry.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 5

## LIFE SCIENCE (LS)

**Topic: Interconnections within Ecosystems**

This topic focuses on foundational knowledge of the structures and functions of ecosystems.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Behavior, Growth and Changes**

**PreK-2:** Living things have basic needs, which are met by obtaining materials from physical environments.

**Grade 5 Concepts**

The content statements for fifth-grade life science are each partial components of a larger concept. The parts have been isolated to call attention to the depth of knowledge required to build to one of biology's foundational theories: dynamic relationships within ecosystems. It is recommended that the content statements be combined and taught as a whole. For example, it is important that the ecological role of organisms is interwoven with a clear understanding that all living things require energy. Virtual simulations and investigations can help demonstrate energy flow through the trophic levels.

Energy flows through an ecosystem in one direction, from photosynthetic organisms to consumers (herbivores, omnivores to carnivores) and decomposers. The exchange of energy that occurs in an ecosystem can be represented as a food web. The exchange of energy in an ecosystem is essential because all processes of life for all organisms require a continual supply of energy.

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.

**Future Application of Concepts**

**Grades 6-8:** Concepts will build for an understanding of the interdependencies and interrelationships of organisms that are required to build stability in an ecosystem.

**High School:** Photosynthesis will be introduced.

**Note: The chemical details of photosynthesis will be addressed in grade 10. This is just an introduction of the process, not the details of the process.**

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design and build a self-sustaining ecosystem (e.g., terrarium, bottle biology). Considerations for the ecosystem include the size of the container, the location to create the proper temperature, light and humidity, and organisms that will support one another. | Investigate change in an established model of an ecosystem over time (e.g., terrarium, aquarium). Answer: ***What would happen if one factor of the environment changes (e.g., temperature increased or decreased, higher intensity of sunlight)?*** Design experiments to observe what actually happens when one environmental factor is changed. | Explain ways that humans can improve the health of ecosystems (e.g., recycling wastes, establishing rain gardens, planting native species).<br><br>**Note: At this grade, species can be defined by using Ernst Mayer's definition of "groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups." Students will not be assessed on the definition of species at this grade level.** | Given a list of common organisms and a description of their environmental interactions, draw a food web using arrows to illustrate the flow of energy. Properly identify the producers and consumers. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Given an ecosystem, create an illustration to explain the flow of energy within that system (food web, food chain). For example, as part of research on an endangered species, the species' energy relationships could be documented in a food web. The focus at this stage is on what eats what in various environments, not the chemical processes of energy transformation and transfer. ODNR-Division of Wildlife's **A to Z Species Guide** has photos, and information, including diet, of Ohio's wild animals.
- 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.
- ***Project Wild*** was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In ***Move Over Rover*** students play a game where they have to identify characteristic animals found in several ecosystems, match those animals to the environments in which they live and identify food chains and food webs within the ecosystems. In ***Surprise Terrarium*** (Wild) and ***Designing a Habitat*** (Aquatic Wild) students design and build habitats for animals.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- **Beyond Penguins and Polar Bears** is an online magazine for K-5 teachers that provides information for misconceptions about plants and how they acquire energy.
- The Annenberg Media series **Essential Science for Teachers** can be used to provide greater insight to misconceptions children hold about living things and energy. Classroom videos and lessons are provided to help students avoid these misconceptions.
- **AAAS' Benchmarks 2061 Online, Chapter 15**, 5e, ***Flow of Matter and Energy***, Plant and Animal Nutrition, outlines children's misconceptions about energy in relationship to producers and consumers.

## DIVERSE LEARNERS

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

- Many ***Project Wild*** activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. In ***Move Over Rover*** students play a game where they have to identify characteristic animals found in several ecosystems, match those animals to the environments in which they live and identify food chains and food webs within the ecosystems. In ***Surprise Terrarium*** (Wild) and ***Designing a Habitat*** (Aquatic Wild) students design and build habitats for animals.

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. The case studies called ***Sarah–Grade 5, Tom–Grade 5***, and ***Erien, Year One–Grade 5*** provide examples of developing meaningful science assessments, learning core science concepts and using effective questioning techniques for scientific inquiry.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 5

## PHYSICAL SCIENCE (PS)

**Topic: Light, Sound and Motion**

This topic focuses on the forces that affect motion. This includes the relationship between the change in speed of an object, the amount of force applied and the mass* of the object. Light and sound are explored as forms of energy that move in predictable ways, depending on the matter through which they move.

### 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.

**Note 1: Gravity and magnetism are introduced (through observation) in PS grade 2.**

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

### CONTENT ELABORATION

**Prior Concepts Related to Force and Motion**

**PreK-2:** Motion is described as a change in position. Forces are introduced as pushes and pulls. Forces are needed to change the motion of objects. Greater force on an object results in a greater change of motion.

**Grades 3-4:** Forces in nature are responsible for water movement, wind movement and movement of sediment through the process of erosion (ESS).

**Grade 5 Concepts:**

The motion of an object can change by speeding up, slowing down or changing direction. Forces cause changes in motion. If a force is applied in the same direction of an object's motion, the speed will increase. If a force is applied in the opposite direction of an object's motion, the speed will decrease. Generally, the greater the force acting on an object, the greater the change in motion. Generally, the more mass* an object has, the less influence a given force will have on its motion. If no forces act on an object, the object does not change its motion and moves at constant speed in a given direction. If an object is not moving and no force acts on it, the object will remain at rest.

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 simulations also can be used to demonstrate speed.

An object that moves with constant speed travels the same distance in each successive unit of time. In the same amount of time, a faster object moves a greater distance than a slower object. When an object is speeding up, the distance it travels increases with each successive unit of time. When an object is slowing down, the distance it travels decreases with each successive unit of time.

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.

**Note 1: This content can be taught in conjunction with the following ESS content: Everything on or anywhere near Earth is pulled toward Earth's center by gravitational force. Weight is a measure of this force. The planets are kept in orbit due to their gravitational attraction for the sun.**

**Note 2: While concepts are related to Newton's second law, remain conceptual at this grade. Knowing the name of the law is not required. Memorizing and reciting words to describe Newton's second law is not appropriate.**

**Note 3: Although mathematics is applied to the concept of speed at this grade level, its use should support deeper understanding of the concept of speed and not be taught as the primary definition of speed.**

BACK TO INDEX

BACK TO K-8 INDEX

**Future Application of Concepts**

**Grades 6-8:** *Force and Motion* involve both magnitude and direction. Two equal forces in opposite directions can give a net force of zero. Position vs. time and speed vs. time graphs are used to represent motion. Fields are introduced for forces that act over a distance.

**High School:** Newton's second law is used to solve mathematical problems in one and two dimensions.

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

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| | **Investigate changes in motion.** | | |
| | Plan and implement a scientific experiment that determines how the mass* of an object (or amount of force acting on an object) affects how the motion of an object changes.<br>Analyze the data to determine trends.<br>Formulate a conclusion. | Represent the data graphically. | Recognize that increasing the force acting on an object will result in greater changes in motion.<br>Recognize that objects with greater mass* will change their motion less than objects with less mass*. |

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Design a way to determine speed from an airplane.** | | | |
| Design a system by which police officers could make observations from an airplane to determine the speed of a car. Give an example of how the speed could be calculated from the measurements. | | Clarify specifically how data will be measured and how it will be used to determine the speed of the car. | Recall the mathematical relationship between distance, time and speed.<br>Identify what factors must be measured to determine speed. |
| | Predict what will happen to the motion of an object. Provide the speed and direction of motion and a force diagram on the object. Explain the prediction. | Compare and rank the relative change in motion for three objects of different masses that experience the same force. | Identify three ways the motion of an object can be changed (e.g., speed up, slow down, change direction).<br>Identify two factors that influence the amount of change in motion of an object. |

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

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- **Common misconceptions** about forces and motion at this grade level include:
  - Time can be measured without establishing the beginning of the interval.
  - The only natural motion is for an object to be at rest.
  - If an object is at rest, no forces are acting on the object.
  - Only animate objects can exert a force. Thus, if an object is at rest on a table, no forces are acting on it.
  - Force is a property of an object.
  - An object has force and when it runs out of force, it stops moving.
  - The motion of an object is always in the direction of the net force applied to the object.
  - Large objects exert a greater force than small objects.
  - A force is needed to keep an object moving with a constant speed.
- **Misconceptions in physical science** at this grade level include:
  - Any quantity can be measured as accurately as you want.
  - The only way to measure time is with a clock or a watch.
  - Time has an absolute beginning.
  - **Gravity only acts on things when they are falling**.
  - Only animate things (people, animals) exert forces; passive ones (tables, floors) do not exert forces.
  - A force applied by a hand (or other object), still acts on an object after the object leaves the hand.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

Donna demonstrates strategies for **working with a diverse group of students** in this video on demand produced by Annenberg. While the content shown does not relate to this content statement, the strategies shown can be adapted to all science content. Once you get to the Annenberg site, select number four, *Donna–Grade 5*.

Sarah demonstrates strategies for **promoting lasting and deep student understanding** in this video on demand produced by Annenberg. While the content shown does not relate to this content statement, the strategies shown can be adapted to all science content.

Tom, a new fifth-grade teacher, works with many special needs students in this video on demand produced by Annenberg. Tom is working to incorporate more **formative assessment** in his teaching and uses strategies such as storyboards and concept mapping to reach his diverse learners. While the content shown does not relate to this content statement, the strategies shown can be adapted to all science content.

Erien, a student teacher in a suburban fifth-grade classroom, is learning how to focus students with **questioning strategies** and manage classroom discussions in this video on demand produced by Annenberg. While the content shown does not align with this content statement, the strategies shown can be adapted to all science content.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 5

## PHYSICAL SCIENCE (PS)

**Topic: Light, Sound and Motion**

This topic focuses on the forces that affect motion. This includes the relationship between the change in speed of an object, the amount of force applied and the mass* of the object. Light and sound are explored as forms of energy that move in predictable ways, depending on the matter through which they move.

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

### 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.

**Note: At this grade level, the discussion of light and sound should be based on observable behavior. Waves are introduced at the middle school level.**

### CONTENT ELABORATION

**Prior Concepts Related to Light and Sound**

**PreK-2:** Sound is related to vibrations (PS). The moon, sun and stars are visible at different times. The sun is the principal source of energy. Sunlight affects the warming and cooling of air, water and land (ESS).

**Grades 3-4:** Objects with energy can cause motion or create change. Energy can transfer between objects and locations. Light energy from the sun can cause plants to grow (LS).

**Grade 5 Concepts:**

Light can travel through some materials, such as glass or water. Light also can travel through empty space, like from the sun to Earth. When light travels from one location to another, it goes in a straight line until it interacts with another object or material. When light strikes objects through which it cannot pass, shadows are formed. As light reaches a new material, it can be absorbed, refracted, reflected or can continue to travel through the new material; one of these interactions may occur or many may occur simultaneously, depending on the material.

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.

When light passes from one material to another, it is often refracted at the boundary between the two materials and travels in a new direction through the new material (medium). For example, a magnifying lens bends light and focuses it toward a single point. A prism bends white light and separates the different colors of light. Experiment with prisms and magnifying lenses to observe the refraction of light.

Visible light may be emitted from an object (like the sun) or reflected by an object (like a mirror or the moon). The reflected colors are the only colors visible when looking at an object. For example, a red apple looks red because the red light that hits the apple is reflected while the other colors are absorbed.

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.

BACK TO INDEX

BACK TO K-8 INDEX

Light travels faster than sound. Technology and virtual simulations 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.

**Note: Students are not responsible for knowing the additive rules for color mixing of light other than the fact that white light is a mixture of many colors. The wave nature of sound and light are not introduced at this level nor are parts of the electromagnetic spectrum other than visible light. At this grade, how sound travels through the medium is not appropriate as atoms and molecules are not introduced until grade 6.**

### Future Application of Concepts

**Grades 6-8:** The atomic nature of matter is introduced and energy is classified as kinetic and potential. Waves are introduced. Energy transfer and transformation, and conservation of energy are explored further.

**High School:** The wave nature of light and sound is expanded upon including mathematical analysis of wavelength, frequency and speed, and the Doppler effect.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate reflection.** | | | |
| Design a mirror system to use when building a periscope. **http://pbskids.org/zoom/activities/sci/periscope.html**<br><br>**Note: Many different ideas for building the exterior structure of the periscope can be found at http://www.sciencetoymaker.org/periscope/index.html. However, please note that in order to meet this cognitive demand, students must be able to experiment to determine the placement of the mirrors. Instructions on how the teacher can make inexpensive mirrors out of old CDs and DVDs can be found at http://www.sciencetoymaker.org/periscope/asmblCD.htm** | Plan and implement a scientific investigation to determine the ideal angle to place a reflective surface to bend light through a right angle. | Draw a picture of the periscope design and trace the path of light as it travels from the object to the eye. | Recognize that the angle that light approaches a reflective surface affects the direction in which the light is reflected. |

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| | **Investigate refraction.** | | |
| | Plan and implement a scientific experiment to investigate what happens when light enters a new medium (e.g., passing from air to water, passing from Jell-O® to air). | Pictorially represent the path light takes when traveling from one medium to another. | Recognize that refraction involves bending of light when passing into a new medium. |
| | **Investigate the relationship between length and pitch.** | | |
| Design two different musical instruments, one using blowing and one using plucking, that can create the same three notes. | Plan and implement a scientific investigation to investigate how the length of PVC tubing affects the pitch of the sound. | Summarize the data in a way that is clear and easy to understand.<br>Verbally explain how the design of the instrument allows different pitches to be produced. | Recognize that longer tubes produce lower pitches and shorter tubes produce higher pitches. |
| | **Explore properties of light and sound.** | | |
| Design, construct and test a laser tag game prototype system that uses a system of mirrors and lenses to direct<br>light through a simple maze to strike targets. | | Draw a picture of a pencil half-submerged in a cup of water. Trace the path of light as it travels from a submerged part of the pencil to the eye. Use this picture to explain why the pencil appears to be bent or broken when placed in water. | Recall that increasing the rate of vibration can increase the pitch of a sound. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The **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 photon 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 photon model.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- Many incorrectly think that sound travels best through air.
- Students have difficulty comprehending that there is no color if there is no light.
- **Students believe** that light just is and has no origin.
- Students believe that the addition of all colors of light yields black.
- **Common misconceptions about sound** pertaining to this content statement and grade level include:
  - Sounds can be produced without using any material objects.
  - Hitting an object harder changes the pitch of the sound produced.
  - Human voice sounds are produced by a large number of vocal cords that all produce different sounds.
  - Loudness and pitch of sounds are the same things.
  - You can see and hear a distinct event at the same moment.
  - Sounds can travel through empty space (a vacuum).
  - Sounds cannot travel through liquids and solids.
  - In wind instruments, the instrument itself vibrates (not the internal air column).
  - Music is strictly an art form; it has nothing to do with science.
  - In actual telephones, sounds (rather than electrical impulses) are carried through the wires.
  - Ultrasounds are extremely loud sounds.
  - Megaphones create sounds.
- **Common misconceptions about light** pertaining to this content statement and grade level include:
  - Light is associated only with a source and/or its instantaneous effects.
  - Light is not considered to exist independently in space.
  - Light is not conceived as moving from one point to another with a finite speed.
  - An object is seen whenever light shines on it, with no recognition that light must move between the object and the observer's eye.
  - A shadow is something that exists on its own.
  - Light pushes the shadow away from the object to a wall, the ground or other surface where the shadow lies.
  - Shadows are "dark reflections" of objects.
  - Lines drawn outward from a light bulb in a sketch represent the "glow" surrounding the bulb.
  - Light from a bulb only extends outward a certain distance and then stops. How far it extends depends on the brightness of the bulb.
  - Light is reflected away from shiny surfaces, but light is not reflected from other surfaces.
  - Light always passes straight through transparent material (without changing direction).
  - When an object is viewed through a transparent material, the object is seen exactly where it is located.
  - Light fills the room as water fills a bathtub.
  - No mechanism between the light, the object and the eye produces vision.

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

Donna demonstrates strategies for **working with a diverse group of students** in this video on demand produced by Annenberg. While the content shown does not relate to this content statement, the strategies shown can be adapted to all science content. Once you get to the Annenberg site, select number four, *Donna–Grade 5*.

Sarah demonstrates strategies for **promoting lasting and deep student understanding** in this video on demand produced by Annenberg. While the content shown does not relate to this content statement, the strategies shown can be adapted to all science content.

Tom, a new fifth-grade teacher, works with many special needs students in this video on demand produced by Annenberg. Tom is working to incorporate more **formative assessment** in his teaching and uses strategies such as storyboards and concept mapping to reach his diverse learners. While the content shown does not relate to this content statement, the strategies shown can be adapted to all science content.

Erien, a student teacher in a suburban fifth-grade classroom, is learning how to focus students with **questioning strategies** and manage classroom discussions in this video on demand produced by Annenberg. While the content shown does not align with this content statement, the strategies shown can be adapted to all science content.

BACK TO INDEX
BACK TO K-8 INDEX

# Grade 6

## INTRODUCTION TO CONTENT STATEMENTS

### GRADE BAND THEME: ORDER AND ORGANIZATION

This theme focuses on helping students use scientific inquiry to discover patterns, trends, structures and relationships that may be described by simple principles. These principles are related to the properties or interactions within and between systems.

### SCIENCE INQUIRY AND APPLICATION

During the years of grades 5-8, all students must use the following scientific processes, with appropriate **laboratory safety techniques**, to construct their knowledge and understanding in all science content areas:

- Identify questions that can be answered through scientific investigations;
- Design and conduct a **scientific investigation**;
- Use appropriate mathematics, tools and techniques to gather data and information;
- Analyze and interpret data;
- Develop descriptions, models, explanations and predictions;
- Think critically and logically to connect evidence and explanations;
- Recognize and analyze alternative explanations and predictions; and
- Communicate scientific procedures and explanations.

### STRANDS

**Strand Connections:** All matter is made of small particles called atoms. The properties of matter are based on the order and organization of atoms and molecules. Cells, minerals, rocks and soil are all examples of matter.

| EARTH AND SPACE SCIENCE (ESS) | PHYSICAL SCIENCE (PS) | LIFE SCIENCE (LS) |
|---|---|---|
| **Topic: Rocks, Minerals and Soil** | **Topic: Matter and Motion** | **Topic: Cellular to Multicellular** |
| This topic focuses on the study of rocks, minerals and soil, which make up the lithosphere. Classifying and identifying different types of rocks, minerals and soil can decode the past environment in which they formed. | This topic focuses on the study of foundational concepts of the particulate nature of matter, linear motion, and kinetic and potential energy. | This topic focuses on the study of the basics of Modern Cell Theory. All organisms are composed of cells, which are the fundamental unit of life. Cells carry on the many processes that sustain life. All cells come from pre-existing cells. |
| **CONDENSED CONTENT STATEMENTS** | | |
| • Minerals have specific, quantifiable properties.<br>• Igneous, metamorphic and sedimentary rocks have unique characteristics that can be used for identification and/or classification.<br>• Igneous, metamorphic and sedimentary rocks form in different ways.<br>• Soil is unconsolidated material that contains nutrient matter and weathered rock.<br>• Rocks, minerals and soils have common and practical uses. | • All matter is made up of small particles called atoms.<br>• Changes of state are explained by a model of matter composed of atoms and/or molecules that are in motion.<br>• There are two categories of energy: kinetic and potential.<br>• An object's motion can be described by its speed and the direction in which it is moving. | • Cells are the fundamental unit of life.<br>• All cells come from pre-existing cells.<br>• Cells carry on specific functions that sustain life.<br>• Living systems at all levels of organization demonstrate the complementary nature of structure and function. |

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Rocks, Minerals and Soil**

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

### CONTENT STATEMENT

**Minerals have specific, quantifiable properties.**

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

### CONTENT ELABORATION

**Prior Concepts Related to Mineral Properties**

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

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

**Grade 6 Concepts**

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

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

**Future Application of Concepts**

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

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

### Career Connection

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

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

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

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

# EARTH AND SPACE SCIENCE (ESS)

**Topic: Rocks, Minerals and Soil**

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

### CONTENT STATEMENT

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

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

### CONTENT ELABORATION

**Prior Concepts Related to Rocks**

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

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

**Grade 6 Concepts**

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

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

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

**Future Application of Concepts**

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

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

BACK TO INDEX

BACK TO K-8 INDEX

MODEL CURRICULUM GRADE 6

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Rocks, Minerals and Soil**

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

### CONTENT STATEMENT

**Igneous, metamorphic and sedimentary rocks form in different ways.**

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

### CONTENT ELABORATION

**Prior Concepts Related to Rocks**

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

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

**Grade 6 Concepts**

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

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

**Future Application of Concepts**

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

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

## COMMON MISCONCEPTIONS

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

BACK TO INDEX

BACK TO K-8 INDEX

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Rocks, Minerals and Soil**

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

### CONTENT STATEMENT

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

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

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

### CONTENT ELABORATION

**Prior Concepts Related to Soil**

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

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

**Grade 6 Concepts**

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

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

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

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

**Future Application of Concepts**

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

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Rocks, Minerals and Soil**

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

### CONTENT STATEMENT

**Rocks, minerals and soils have common and practical uses.**

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

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

### CONTENT ELABORATION

**Prior Concepts Related to Uses of Rocks, Minerals and Soil**

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

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

**Grade 6 Concepts**

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

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

**Future Application of Concepts**

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

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

## LIFE SCIENCE (LS)

**Topic: Cellular to Multicellular**

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

### CONTENT STATEMENT

**Cells are the fundamental unit of life.**

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

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

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

### CONTENT ELABORATION

**Prior Concepts Related to Species and Reproduction**

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

**Grades 3-5:** Organisms are made of parts.

**Grade 6 Concepts:**

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

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

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

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

**Future Application of Concepts**

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

BACK TO INDEX

BACK TO K-8 INDEX

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

## LIFE SCIENCE (LS)

**Topic: Cellular to Multicellular**

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

### CONTENT STATEMENT

**All cells come from pre-existing cells.**

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

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

### CONTENT ELABORATION

**Prior Concepts Related to Species and Reproduction**

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

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

**Grade 6 Concepts**

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

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

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

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

**Future Application of Concepts**

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Prepare slides with a variety of **cell samples** for viewing under the microscope to examine a variety of cells. The cells should be from different parts of the organism and from different organisms. Make comparisons between the cells based on their locations and origins. Explain why they have the structure and function that they do. **Oklahoma City Community College's website** has detailed information on how to use a microscope. Click on the *Biology* button, then click *Introduction to the Microscope*. Using information from observations and cell research, build a model of a cell. This **organizational tool** can be used to document findings.
- **Cells Alive** and **the University of Utah** offer an interactive animated view of the interior of the cell. The organelles and their functions are the focus.
- 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.
- **Vision Learning** provides teacher background information about the cell and its discovery.

## COMMON MISCONCEPTIONS

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

BACK TO INDEX

BACK TO K-8 INDEX

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

## LIFE SCIENCE (LS)

**Topic: Cellular to Multicellular**

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

### CONTENT STATEMENT

**Cells carry on specific functions that sustain life.**

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

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

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

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

### CONTENT ELABORATION

**Prior Concepts Related to Organisms and Reproduction**

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

**Grades 3-5:** Organisms are made of parts.

**Grade 6 Concepts**

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

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

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

**Future Application of Concepts**

**Grades 7-8:** Photosynthesis and respiration are compared.

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

## LIFE SCIENCE (LS)

**Topic: Cellular to Multicellular**

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

### CONTENT STATEMENT

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

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

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

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

### CONTENT ELABORATION

**Prior Concepts Related to Organisms and Reproduction**

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

**Grades 3-5:** Organisms are made of parts.

**Grade 6 Concepts**

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

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

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

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

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

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

**Future Application of Concepts**

**Grade 8:** Cellular reproduction is studied.

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Test the effectiveness of a cellular leavening agent (yeast) for making bread under different conditions (varying the amount of sugar, the type of flour, the type of sugar). After multiple trials, determine which recipe makes the least dense bread (as represented by air spaces). | Conduct an investigation to determine the rate of respiration in yeast cells by varying sugar concentrations or other variables to determine the maximum release of carbon dioxide.<br><br>**Note: Do not conduct a splint test for carbon dioxide.** | Compare the four major types of tissues (epithelial, connective, nerve and muscle tissue). | Identify general distinctions among the cells of organisms that support classifying some as plants, some as animals and some that do not fit neatly into either group. |
| | Conduct an investigation to determine the rate of photosynthesis in plants to maximize oxygen production. | | |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

BACK TO INDEX
BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

# PHYSICAL SCIENCE (PS)

**Topic: Matter and Motion**

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

### CONTENT STATEMENT

**All matter is made up of small particles called atoms.**

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

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

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

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

### CONTENT ELABORATION

**Prior Concepts Related to Matter**

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

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

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

**Grade 6 Concepts**

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

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

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

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

BACK TO INDEX

BACK TO K-8 INDEX

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

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

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

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

### Future Application of Concepts

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

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

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

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

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

# PHYSICAL SCIENCE (PS)

**Topic: Matter and Motion**

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

### CONTENT STATEMENT

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

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

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

Mass is conserved when substances undergo changes of state.

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

### CONTENT ELABORATION

**Prior Concepts Related to States of Matter**

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

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

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

**Grade 6 Concepts**

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

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

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

BACK TO INDEX

BACK TO K-8 INDEX

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

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

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

### Future Application of Concepts

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

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

## COMMON MISCONCEPTIONS

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

BACK TO INDEX

BACK TO K-8 INDEX

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

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

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

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

## PHYSICAL SCIENCE (PS)

**Topic: Matter and Motion**

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

### CONTENT STATEMENT

**There are two categories of energy: kinetic and potential.**

Objects and substances in motion have kinetic energy.

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

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

### CONTENT ELABORATION

**Prior Concepts Related to Energy**

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

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

**Grade 6 Concepts**

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

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

**Future Application of Concepts**

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

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

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

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

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 6

# PHYSICAL SCIENCE (PS)

**Topic: Matter and Motion**

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

### CONTENT STATEMENT

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

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

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

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

### CONTENT ELABORATION

**Prior Concepts Related to Forces and Motion**

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

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

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

**Grade 6 Concepts**

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

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

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

BACK TO INDEX

BACK TO K-8 INDEX

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

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

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

### Future Application of Concepts

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

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

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

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

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

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

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

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

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

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

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

BACK TO INDEX
BACK TO K-8 INDEX

# Grade 7

## INTRODUCTION TO CONTENT STATEMENTS

### GRADE BAND THEME: ORDER AND ORGANIZATION

This theme focuses on helping students use scientific inquiry to discover patterns, trends, structures and relationships that may be described by simple principles. These principles are related to the properties or interactions within and between systems.

#### SCIENCE INQUIRY AND APPLICATION

- During the years of grades 5-8, all students must use the following scientific processes, with appropriate **laboratory safety techniques**, to construct their knowledge and understanding in all science content areas:
- Identify questions that can be answered through scientific investigations;
- Design and conduct a **scientific investigation**;
- Use appropriate mathematics, tools and techniques to gather data and information;
- Analyze and interpret data;
- Develop descriptions, models, explanations and predictions;
- Think critically and logically to connect evidence and explanations;
- Recognize and analyze alternative explanations and predictions; and
- Communicate scientific procedures and explanations.

#### STRANDS

**Strand Connections:** Systems can exchange energy and/or matter when interactions occur within systems and between systems. Systems cycle matter and energy in observable and predictable patterns.

| EARTH AND SPACE SCIENCE (ESS) | PHYSICAL SCIENCE (PS) | LIFE SCIENCE (LS) |
|---|---|---|
| **Topic: Cycles and Patterns of Earth and the Moon**<br>This topic focuses on Earth's hydrologic cycle, patterns that exist in atmospheric and oceanic currents, the relationship between thermal energy and the currents, and the relative position and movement of the Earth, sun and moon. | **Topic: Conservation of Mass and Energy**<br>This topic focuses on the empirical evidence for the arrangements of atoms on the Periodic Table of Elements, conservation of mass and energy, transformation and transfer of energy. | **Topic: Cycles of Matter and Flow of Energy**<br>This topic focuses on the impact of matter and energy transfer within the biotic component of ecosystems. |

BACK TO INDEX

BACK TO K-8 INDEX

## CONDENSED CONTENT STATEMENTS

- The hydrologic cycle illustrates the changing states of water as it moves through the lithosphere, biosphere, hydrosphere and atmosphere.
- Thermal-energy transfers in the ocean and the atmosphere contribute to the formation of currents, which influence global climate patterns.
- The atmosphere has different properties at different elevations and contains a mixture of gases that cycle through the lithosphere, biosphere, hydrosphere and atmosphere.
- 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 properties of matter are determined by the arrangement of atoms.
- Energy can be transformed or transferred but is never lost.
- Energy can be transferred through a variety of ways.
- Matter is transferred continuously between one organism to another and between organisms and their physical environments.
- In any particular biome, the number, growth and survival of organisms and populations depend on biotic and abiotic factors.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 7

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Cycles and Patterns of Earth and the Moon**

This topic focuses on Earth's hydrologic cycle, patterns that exist in atmospheric and oceanic currents, the relationship between thermal energy and the currents, and the relative position and movement of the Earth, sun and moon.

### 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.

**Note: Contamination can occur within any step of the hydrologic cycle. Ground water is easily contaminated as pollution present in the soil or spilled on the ground surface moves into the ground water and impacts numerous water sources.**

### CONTENT ELABORATION

**Prior Concepts Related to Hydrologic Cycle**

**PreK-2:** Water is observed through weather. Water is in the atmosphere. Water can be a solid, a gas and a liquid.

**Grades 3-5**: Water is present in soil. Water is a non-living resource. Properties of the different states of water, how water can change the surface of Earth, and how water is a factor in some weather-related events (e.g., flooding, droughts) are discussed.

**Grade 6:** The changes in the state of water are related to motion of atoms (changes in energy). Water flows through rock and soil (porosity and permeability).

**Grade 7 Concepts**

The different pieces of the hydrologic cycle (e.g., properties of water, changes of state, relationships of water to weather, effects of water on Earth's surface) from the elementary grades are formally combined in grade 7 and applied to the components of the hydrologic cycle.

The movement of water through the spheres of Earth is known as the hydrologic cycle. As water changes state and energy is transferred, it cycles from one sphere into another (e.g., water transfers from the hydrosphere to the atmosphere when evaporation occurs). Ground water and surface water quality are important components of the hydrologic cycle. The porosity and permeability of the rock and/or soil (grade 6) can affect the rate at which the water flows. The pattern of the cycling illustrates the relationship between water, energy and weather.

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.

**Future Application of Concepts**

**Grade 8:** The relationship between the hydrosphere, atmosphere and lithosphere are studied as they relate to weathering and erosion.

**High School:** The hydrologic cycle is a component of biology as it relates to ecosystems and the diversity of life.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Produce and test solutions for reducing acid rain, erosion and/or surface runoff rates in specific regions (e.g., urban, agricultural, construction). Present findings/plan to school administrators or local government. | Design and conduct a scientific investigation to measure and analyze surface-water discharge rates. | Using GPS/GIS programs, topographic maps and/or aerial maps, identify regions where surface water run-off and/or acid rain could impact ground or surface water quality. Illustrate the results graphically. | Describe the movement of water through all four spheres of Earth (lithosphere, hydrosphere, atmosphere, biosphere). |
| Develop, test and evaluate plans outlining a specific method to reduce storm water flow at a specific site in the local community (e.g., a housing construction project, the school parking lot). Present findings/plans to school administrators or local government. | Build a model to represent a cross-section of Earth's surface (soil, rock, surface, ground water) that can enable investigation of multiple water pathways. Explain and demonstrate to the class. | Research and investigate an area in Ohio that exhibits a unique water contamination problem (e.g., acid mine drainage in southeastern Ohio, mercury contamination in Lake Erie). Document recent discoveries, case studies, clean-up technologies or field investigations that are occurring. Present findings to the class. | Identify the changes in thermal energy as water changes state in the hydrologic cycle. |
| | Investigate and use different methods and tools that measure water flow and water quality, and evaluate which methods and tools are most effective for the desired outcome. | Research and evaluate the effectiveness of different tools, models and methods to collect ground water and surface water data (e.g., rate of flow, direction of movement, types of contamination). Present recommendations orally, graphically or in writing. | Recognize that the sun is the source of energy that drives the hydrologic cycle. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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** website 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.

### Career Connection

Students will research or investigate an actual environmental event (e.g., a specific release of a toxin or contaminant) and determine how it impacted each of Earth's spheres. Students will identify a body of water that has been flagged as an environmental hazard. They will identify careers needed to assist in analyzing the problem, developing a solution, and acting to resolve the issue. Students will identify which organizations and agencies to consult, how they will mobilize the necessary resources, and their specific role in the project.

## COMMON MISCONCEPTIONS

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

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**.

Teachers need to sign up to use this free site. The case studies *Dotty–Grade 7* and *Erien, Year Two–Grade 7* provide examples of how to use technology in the science classroom and develop higher-level thinking for science students.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 7

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Cycles and Patterns of Earth and the Moon**

This topic focuses on Earth's hydrologic cycle, patterns that exist in atmospheric and oceanic currents, the relationship between thermal energy and the currents, and the relative position and movement of the Earth, sun and moon.

### 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.

**Note: This content statement is related to LS grade 7 (biomes). Regional temperature and precipitation contribute to the identification of climatic zones.**

### CONTENT ELABORATION

**Prior Concepts Related to Energy Transfers, Atmosphere and Hydrosphere**

**PreK-2:** Water is observed through weather. Water is in the atmosphere. Water can be a solid, a gas and a liquid.

**Grades 3-5:** Water is present in soil. Water is a non-living resource. Properties of the different states of water, how water can change the surface of Earth, and how water is a factor in some weather-related events (e.g., flooding, droughts) are discussed.

**Grade 6:** The changes in the state of water are related to motion of atoms. Atoms take up space and have mass. Changes of state occur due to the amount of motion of atoms and molecules and density.

**Grade 7 Concepts**

The earlier concepts of weather and the physical properties of air and water and their changes are expanded in grade 7 to the relationship of atmospheric and oceanic currents and climate. Current and climate patterns on a global level should be studied using a variety of maps, models and technology (e.g., remote sensing, satellite images, LANDSAT).

The causes of moving currents in the atmosphere and ocean must be connected to thermal energy, density, pressure, composition and topographic/geographic influences (e.g., continental mountains, ocean ridges). Studies also should include **specific current patterns** in both the atmosphere and the ocean that are mapped and documented through data. Contemporary studies regarding global climate must be based on **facts and evidence**.

This content statement is connected to the LS grade 7 content pertaining to biomes and the climatic zones of Earth.

**Future Application of Concepts**

**Grade 8:** In grade 8, global climate is expanded though the investigation of **climate change** that occurred throughout Earth's history (as evidenced through the rock record and more recently though ice cores).

**High School:** Gravity, density, gases and properties of air and water are found in Physical Sciences. In the 11/12 grade Physical Geology and Environmental Science courses, climate change is explored in greater depth.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate 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** (Demonstrating Science Knowledge), develop a list of criteria (including cost) for successful buoy deployment and life span.<br><br>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.<br><br>Additional buoy data is available at **NOAA Drifter Buoy Program**. | Adopt a drifter buoy (**NOAA**), record its movement and record water-temperature data over time.<br><br>Represent the **oceanic data** on a graph or chart to assist in the analysis and interpretation found under Demonstrating Science Knowledge. | Identify the factors that contribute to the global climate. |
| **Investigate the velocity of ocean and atmospheric currents.** | | | |
| The movement of ocean and atmospheric currents directly influence climate. Changes in velocity (speed and direction) can be measured and used to predict climate pattern changes. | | | |
| Using the analytical data from Demonstrating Science Knowledge, evaluate and map the fastest and most effective route to travel from Spain to<br><br>Florida. Document all scientific data, data analysis and steps in the evaluation process (everything that supports the chosen route). | Using Adopt a Buoy data (**NOAA**), calculate the average buoy velocities at specific segments of the year.<br><br>Predict where ocean current patterns change and may result in climate changes (based on the data). ***How does this relate to Jet Stream patterns and changes?*** Present findings to the class and be prepared to defend the predictions using evidence and data. | Record drifter-buoy **velocity** data in a graph or chart. Use the velocity data to make a simple map showing the general patterns of the Gulf Stream. Research the documented patterns of the **Jet Stream.** | Identify the general patterns of the Jet<br><br>Stream and the Gulf Stream using a world map. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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.
- Integrate the previously listed investigations with both physical science and life science for grade 7 so students see connections between the content. For PS, measure and calculate the **velocity** of the Gulf Stream at varying intervals over a period of time using real-time buoy data. For LS, calculate the ocean productivity level (**biomass**) for specific areas within the Gulf Stream. Analyze the data to determine the **relationships** between water temperatures, amounts of living organisms and types of living organisms present.
- Integrate the previously listed investigations with other content areas (e.g., Mathematics, English Language Arts, Social Studies, World Languages, Fine Arts) using the *Eye of Integration*. This demonstrates the interconnectedness of STEM fields and other middle school content areas, ensuring that real-world connections are made through different lenses.

## COMMON MISCONCEPTIONS

- Students may have misinformation and misconceptions that pertain to climate change. To address this, it is important to provide scientific evidence of climate change throughout Earth's history (found in grade 8 ES) and current data to document temperature changes (surface and oceanic). Data and other resources to help with teaching climate change can be found on EPA's website at **http://www.epa.gov/climatechange/index.html**.
- **NASA** provides lists of common misconceptions that pertain to Earth and the patterns and cycles on Earth. By teaching students through Earth systems and allowing exploration of the interconnectedness of the systems, students can become aware of the role climate has played throughout Earth's history.
- Carleton College provides geology-specific assessment techniques that can identify misconceptions, lists of common Earth science misconceptions and resources to correct misconceptions at **http://serc.carleton.edu/NAGTWorkshops/teaching_methods/conceptests/index.html**.
- NASA provides a list of overarching Earth Science questions that address many of the common misconceptions at this grade level. There are resources and information that help address questions that center on Earth Systems Science at **http://science.nasa.gov/big-questions/**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies *Dotty–Grade 7* and *Erien, Year Two–Grade 7* provide examples of how to use technology in the science classroom and develop higher-level thinking for science students.

BACK TO INDEX
BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 7

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Cycles and Patterns of Earth and the Moon**

This topic focuses on Earth's hydrologic cycle, patterns that exist in atmospheric and oceanic currents, the relationship between thermal energy and the currents, and the relative position and movement of the Earth, sun and moon.

### 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.

**Note: The emphasis is on why the atmosphere has defined layers, not on naming the layers.**

### CONTENT ELABORATION

**Prior Concepts Related to Atmosphere**

**PreK-2:** Wind is felt as moving air, wind speed and direction can be measured, sunlight warms air, the atmosphere is air, air has properties, transfer of energy causes air movement, and water is present in air.

**Grades 3-5:** Air is a non-living resource that can be used for energy, air can be contaminated, wind can change the surface of Earth, and Earth is a planet that has an atmosphere.

**Grade 6:** Atoms take up space, have mass and are in constant motion. Elements, molecules and compounds (and their properties) are discussed. Changes of state occur due to the amount of motion of atoms and molecules.

**Grade 7 Concepts**

The properties and composition of the layers of Earth's atmosphere are studied, as they are essential in understanding atmospheric current, climate and biogeochemical cycles, which are seventh-grade concepts.

Understanding the interactions between Earth's spheres (Earth Systems Science) and how specific elements and/or molecules move between them should be emphasized. This study must include standard greenhouse gases (including water vapor), ozone (in the atmosphere and at Earth's surface), and natural events/human activities that can change the properties of the atmosphere. Contemporary issues and technological advances should be included within this concept. Real-time scientific data pertaining to air quality and properties of air must be incorporated into the study of atmospheric properties and air quality.

**Future Application of Concepts**

**Grade 8:** Changes in environmental and climate conditions (including atmospheric changes) as evidenced in the rock record and contemporary studies of ice cores are studied.

**High School:** Gravity, density, gases and properties of air are found in the Physical Science course. In grade 11/12 Physical Geology and Environmental Science courses, the atmosphere, Clean Air Act and climate change are explored further.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Develop a method of testing and evaluating the best material to use in a physical filtration mask used by humans that are exposed to particulate matter (e.g., mold, dust, soil, ash). Compile and analyze test methods and data. Present final recommendations (based on the scientific evidence) to the class. | Plan and implement an investigation to collect and test ground levels of ozone or carbon monoxide in a local area. Compare results to statewide data. Determine the existing factors that contribute to these levels. Explain and defend the investigation and the results to an authentic audience. | Using **ozone data** from the stratospheric level, generate a graph that illustrates the changes in the ozone over a specific period of years. | Identify the general properties of the different layers of the atmosphere.<br>Recognize human-made and natural factors that can change the properties of the atmosphere. |
| | Plan and implement an investigation to test the relationship between air pressure, elevation and temperature. Determine where to find reliable datasets that can be used to verify the hypothesis. Analyze the data and make a final determination. Write a final analysis and conclusion to share with the class. | Research and document the types of everyday activities that generate the highest and lowest amount of air pollution. Compare the results with the class. | Identify the different gases that are present in Earth's atmosphere.<br>Trace the different biogeochemical cycles through each of Earth's spheres. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The 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.

## COMMON MISCONCEPTIONS

- Students may have misinformation and misconceptions that pertain to climate change. To address this, it is important to provide evidence of climate change throughout Earth's history and current data to document temperature changes (surface and oceanic). Data and other resources to help with teaching climate change can be found on EPA's website at **http://www.epa.gov/climatechange/index.html**.
- NASA lists common misconceptions for all ages about the sun and the Earth at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- Offered by NASA, Mission: Science provides games and activities for students that can supplement what is being learned in the classroom. Interactive computer games based on accurate science can be used to generate interest and support classroom work. Find it at **http://missionscience.nasa.gov/**.
- NASA provides a list of overarching Earth Science questions that address many of the common misconceptions at this grade level. There are resources and information that help address questions that center on Earth Systems Science at **http://science.nasa.gov/big-questions/**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies *Dotty–Grade 7* and *Erien, Year Two–Grade 7* provide examples of how to use technology in the science classroom and develop higher-level thinking for science students.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 7

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Cycles and Patterns of Earth and the Moon**

This topic focuses on Earth's hydrologic cycle, patterns that exist in atmospheric and oceanic currents, the relationship between thermal energy and the currents, and the relative position and movement of the Earth, sun and moon.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Moon, Earth and Sun**

**PreK-2:** The moon, sun and stars can be observed at different times of the day or night. The observable shape of the moon changes throughout the month. The sun's position in the sky changes in a single day and from day to day. The sun is the principal source of energy.

**Grades 3-5:** Earth's atmosphere, introduction to gravitational forces, orbits of planets and moons within the solar system, predictable cycles and patterns of motion between the Earth and sun, and the fact that Earth's axis is tilted are explored.

**Grade 6:** Objects and substances in motion have kinetic energy. Objects and substances can store energy as a result of its position (gravitational potential energy).

**Grade 7 Concepts**

The role of gravitational forces and tides are introduced in relationship to the position of the Earth, moon and sun. Models and simulations (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. Earth and its solar system are part of the Milky Way galaxy, which are part of the universe.

The emphasis should not be on naming the phases of the moon or tides, but in understanding why the phases of the moon or tides are cyclical and predictable. Advances in science knowledge regarding patterns and movement in the solar system are included in this content statement.

**Future Application of Concepts**

**Grade 8:** Gravitational forces, frame of reference, forces have magnitude and direction, and gravitational potential energy are explored.

**High School:** Patterns of motion within the solar system are expanded to the universe. The Big Bang theory and origin of the universe are explored. Forces and motion are investigated at depth.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Research the availability of tidal-generated power facilities. Outline the requirements and output. Critique and analyze all collected data. Using tidal and current requirements (and other physical requirements, such as ocean depth, geographic location), make a determination of a recommended location for maximum effectiveness within the United States. | Design and conduct an experiment using 3-D modeling, drawing or technology to represent the factors that must exist for a full or partial solar or lunar eclipse. Use actual data to create the model. Present with detailed explanation to the class. | Make a chart or graph that illustrates moon phases, Earth's rotation, sun position and resulting tidal data for one month. Include specific data about<br>Spring and Neap tides. Use actual data to document the graphic representation. | Recognize the relationship between gravity and tidal movement.<br>Recognize the different phases of the moon. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Teaching concepts of tides and eclipses must involve student-centered modeling and exploration. These topics can be abstract, even if they have been observed. Developing modeling strategies and research-based investigations can lead to a deeper understanding of the processes involved in different eclipses and tidal patterns. **NASA** provides examples, data and resources to assist in teaching about tides and eclipses using models.
- 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.
- **Griffith Observatory** provides background data and information pertaining to lunar phases, eclipses and celestial bodies.

## COMMON MISCONCEPTIONS

- NASA lists common misconceptions for all ages about the sun and the Earth at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- NASA provides a list of overarching Earth Science questions that address many of the common misconceptions at this grade level. There are resources and information that help address questions that center on Earth Systems Science at **http://science.nasa.gov/big-questions/**.

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case studies *Dotty–Grade 7* and *Erien, Year Two–Grade 7* provide examples of how to use technology in the science classroom and develop higher-level thinking for science students.

BACK TO INDEX
BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 7

## LIFE SCIENCE (LS)

**Topic: Cycles of Matter and Flow of Energy**

This topic focuses on the impact of matter and energy transfer within the biotic component of ecosystems.

### CONTENT STATEMENT

**Matter is transferred continuously between one organism to another and between organisms and their physical environments.**

Plants use the energy in light to make sugars out of carbon dioxide and water (photosynthesis). These materials can be used and immediately stored for later use. Organisms that eat plants break down plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms.

Energy can transform from one form to another in living things. Animals get energy from oxidizing food, releasing some of its energy as heat.

The total amount of matter and energy remains constant, even though its form and location change.

**Note 1: Chemical reactions are presented as the rearrangement of atoms in molecules.**

**Note 2: Chemical reactions in terms of subatomic structures of atoms are not appropriate.**

### CONTENT ELABORATION

**Prior Concepts Related to Cycles of Matter and Flow of Energy**

**Grades 3-5:** Populations of organisms can be categorized by how they acquire energy. Food webs can be used to identify the relationships among organisms. 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.

**Grade 6:** Atomic Molecular Theory, Cell Theory and the function of cell organelles, including mitochondria and chloroplast, are studied.

**Grade 7 Concepts**

The basic concepts for matter and energy flow were introduced in grades 3-5. The grades 3-5 concepts are expanded to include a comparison of photosynthesis and cellular respiration.

The use of light energy to make food is called photosynthesis. The breakdown of food to release the stored energy is called respiration. General formulas are appropriate at this grade level, because atoms and molecules are taught in grade 6. Details of both processes are not grade appropriate. In grade 6, cellular organelles are introduced. It is appropriate to reinforce that the chloroplast (the plant cell organelle that contains chlorophyll) captures the sun's energy to begin the process of converting the energy from the sun into sugars and sugar polymers, such as starch.

As matter is cycled within the environment, it promotes sustainability. The emphasis is not on food webs, but on the transfer of matter and energy between organisms. The total amount of matter and energy remains constant in an ecosystem, even though the form and location undergo continual change. The concept of conservation of matter (introduced in PS grade 4) and conservation of energy are applied to ecosystems. An energy pyramid graphic can illustrate the flow of energy. At each stage in the transfer of energy within an ecosystem, some energy is stored in newly synthesized molecules and some energy is lost into the environment as heat produced by the chemical processes in cells. The elements that make up the molecules of living things are continuously recycled. Energy rich molecules that are passed from organism to organism are eventually recycled by decomposers back into mineral nutrients usable by plants.

New discoveries, technology and research must be used to connect the concept of energy transfer and transformation within the ecosystem and between ecosystems. For example, the use of biomass as an alternative energy source for the local area can focus on different types of biomass, competition between human food crops and biomass crops, and biomass vs. other types of alternatives to fossil-fuels energy.

**Future Application of Concepts**

**High School:** The chemical flow of energy during reactions will be explored as the molecular structure of molecules is studied.

BACK TO INDEX

BACK TO K-8 INDEX

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Ethanol, a plant product, is used in place of fossil fuels. Evaluate the pros and cons of using biomass products such as ethanol vs. traditional fossil fuels. Include in the evaluation anticipated real-world effects for production and usage of biomass products vs. traditional fossil fuels. | Plan and conduct an investigation to determine what factors impact photosynthesis in plants that live in aquatic environments (Elodea). | Distinguish between photosynthesis and respiration and illustrate how the two processes are connected. Create a chart that compares the reactants and products of both processes. | Identify the cellular structures primarily responsible for photosynthesis and respiration. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The Annenberg Media series *Essential Science for Teachers:* **Life Science: Session 8** provides examples of material cycling in an ecosystem while illustrating the difference between the flow of energy and the cycling of materials.

## COMMON MISCONCEPTIONS

- **Weber State University** provides a list for misconceptions in biology. Scroll down to Standard I to address misconceptions about energy flow in an ecosystem.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study *Dotty–Grade 7* provides examples of how to use technology in the science classroom and develop higher-level thinking for science students.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 7

## LIFE SCIENCE (LS)

**Topic: Cycles of Matter and Flow of Energy**

This topic focuses on the impact of matter and energy transfer within the biotic component of ecosystems.

### 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.

**Note: Predator-prey and producer-consumer relations are addressed in grade 5.**

### CONTENT ELABORATION

**Prior Concepts Related to Forces, Movement and Igneous Environments**

**PreK-2:** Plants and animals have traits that improve their chances of living in different environments. Living things have basic needs, which are met by obtaining materials from the physical environment.

**Grades 3-5:** Populations of organisms can be categorized by how they acquire energy. Food webs can be used to identify the relationships among organisms. 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.

**Grade 7 Concepts**

Biomes are defined by abiotic components of the environment – topography, soil types, precipitation, solar radiation and temperature. Comparing the different biomes found on Earth is the focus of this content statement. Examples of the Earth's biomes include aquatic (freshwater, brackish water and marine water), forest (tropical and temperate), desert (cold and hot), grassland, taiga and tundra. Biomes must be linked to climate zones on a global level by using a variety of maps, models and technology (e.g., remote sensing, satellite images, LANDSAT). This content statement is connected to the ESS middle school content pertaining to global climate patterns.

An ecosystem is composed of linked and fluctuating interactions between biotic and abiotic factors. Given adequate resources and an absence of disease or predators, populations of organisms in ecosystems increase at rapid rates. Finite resources and other factors limit population growth. As one population proliferates, it is held in check by one or more environmental factors (e.g., depletion of food or nesting sites, increased loss to predators, invasion by parasites). If a natural disaster such as a flood or fire occurs, the damaged ecosystem is likely to recover in a succession of stages that eventually results in a system similar to the original one.

**Future Application of Concepts**

**High School:** The evolutionary mechanisms that build unity and diversity are studied.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Analyze or critique the impact of Ohio's wetland mitigation plans on a local community or the state as a whole. Include real-world data from the sites in the analysis or critique. Anticipate future trends on the flora and fauna in the ecosystem based upon the real-world data. | Monitor the local environment (e.g., stream, river, construction site) for the impact Ohio's wetland mitigation plans have on water quality (e.g., oxygen levels, pH, phosphorus levels, nitrogen levels) and how the plans will impact living organisms (e.g., algae, diatoms, mussels, insect larvae). | Trace and explain how matter and energy are transferred through an ecosystem. | Identify the biotic and abiotic elements of the major biomes and describe how they are connected. |
| | | Research an endangered species and examine environmental conditions that may contribute to that organism's classification. Determine if any conservation efforts have been employed and document whether or not any efforts have been successful. Use evidence to support responses. | |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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** provide 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. The Encyclopedia of Life and Atlantic Public Media developed this program.
- The Annenberg Media series **Habitable Planet** explores how changes in populations impact ecosystems. It also shows how data is collected in the field.
- **Colorado University** has information about how animal population data can be collected in the Arctic with unmanned aircraft.
- 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 photos of various species of plants interacting with one another and the environment and examine what changes result due to those interactions.
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. Several *Project Wild* and *Project Wild Aquatic* activities support this content. ***How Many Bears Can Live in This Forest?*** - This activity explores how changes in an ecosystem impact the survival of an organism. ***Oh Deer!*** - This activity explores how fluctuations in an environment impact the survival of an organism. ***Planting Animals*** - This activity explores the positive and negative implications of" translocating" wildlife in an ecosystem. ***Checks and Balances*** — Students become managers of a herd of animals in a conceptual and discussion-based activity where they identify at least four factors that can affect the size of a wildlife population. ***Water Canaries (Aquatic WILD)*** - Students investigate a stream or pond to identify aquatic organisms and assess the relative quality of the stream or pond. ***Migration Headaches*** - Students portray migrating waterfowl and experience limiting factors along their migration paths.

## COMMON MISCONCEPTIONS

- **Weber State University** provides a list for misconceptions in biology. Scroll down to Standard I to address misconceptions about interactions between organisms in an ecosystem.

## DIVERSE LEARNERS

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

- Many *Project Wild* activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. ***How Many Bears Can Live in This Forest?*** - This activity explores how changes in an ecosystem impact the survival of an organism. ***Oh Deer!*** - This activity explores how fluctuations in an environment impact the survival of an organism. ***Planting Animals*** - This activity explores the positive and negative implications of" translocating" wildlife in an ecosystem. ***Checks and Balances*** — Students become managers of a herd of animals in a conceptual and discussion-based activity where they identify at least four factors that can affect the size of a wildlife population. ***Water Canaries (Aquatic WILD)*** - Students investigate a stream or pond to identify aquatic organisms and assess the relative quality of the stream or pond. ***Migration Headaches*** - Students portray migrating waterfowl and experience limiting factors along their migration paths.

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

A series of case studies of K-8 science classrooms by the Smithsonian and Harvard University can be found at **http://www.learner.org/resources/series21.html**. Teachers need to sign up to use this free site. The case study ***Dotty–Grade 7*** provides examples of how to use technology in the science classroom and develop higher-level thinking for science students.

BACK TO INDEX
BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 7

## PHYSICAL SCIENCE (PS)

**Topic: Conservation of Mass and Energy**

This topic focuses on the empirical evidence for the arrangements of atoms on the Periodic Table of Elements, conservation of mass and energy, transformation and transfer of energy.

### 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.

**Note 1: This is the conceptual introduction of the Periodic Table of Elements.**

**Note 2: Acids and bases are included in this topic; further detail will be provided in the Model Curriculum.**

**Note 3: It is important to emphasize that most changes in the properties of matter have some combination of chemical and physical change (at different levels).**

### CONTENT ELABORATION

**Prior Concepts Related to Properties of Matter**

**PreK-2:** Properties can be used to sort objects. Changes, including phase changes are explored.

**Grades 3-5:** Objects are composed of matter which has mass* and volume. Properties of solids, liquids and gases are explored. Phase changes are reversible and do not change the identity of the material. The total amount of matter and mass* remains the same when something changes.

**Grade 6:** All matter is made up of atoms that are in constant random motion. Elements, compounds and molecules are introduced. The properties of solids, liquids and gases, and changes of phase are explained by the motion and spacing of the particles.

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

**Grade 7 Concepts:**

Mixtures are materials composed of two or more substances that retain their separate atomic compositions, even when mixed (e.g., water and sugar can be mixed together thoroughly at the molecular level but the water particles and sugar particles remain separate).

Elements are organized into groups based on their properties (including melting and/or boiling points) and position on the periodic table. These groups include metals, non-metals and gases that are almost completely nonreactive. The nonreactive gases exist primarily as elements and do not react to form many compounds. Most metals are malleable, have high melting points, are usually solid at room temperature and are good conductors of heat and electricity. Nonmetals are poor conductors of heat and electricity, are usually gases at room temperature and, as solids, tend to be dull and brittle.

The pH scale has a range of 0-14 and is used to measure the acidity or alkalinity of a compound. At the seventh-grade level, pH tests must be conducted on a variety of substances. The properties of the compounds that are acidic (below 7 on the pH scale), neutral (7 on the pH scale) or basic (above 7 on the pH scale) must be compared and evaluated. Acidity and alkalinity values must be related and connected to the natural world, as pH values are used to measure water, soil and air quality (e.g., sulfuric acid in the atmosphere can form acidic precipitation which can impact the acidity of a stream and the living organisms in the stream). The discussion of hydroxide and hydrogen ions as they relate to the pH scale is reserved for high school and will not be assessed at the grade 7.

BACK TO INDEX

BACK TO K-8 INDEX

**Chemical and physical changes** occur on a continuum and no distinct lines separate the two. In many cases when objects, substances or materials undergo change, there may be a combination of chemical and physical changes occurring. Under these standards, classifying specific changes as chemical or physical is not appropriate.

For any change in a closed system, the number and type of atoms stays the same, even if the atoms are rearranged. Therefore, the mass remains constant.

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

**Note 2: $H^+$ and $OH^-$ ions as they relate to pH are found at the high school level.**

**Note 3: While mass is always conserved, this is not the case for volume. Mixing alcohol with water results in a volume that is less than the sum of the volumes. Boiling liquid results in a significant increase in volume.**

**Note 4: The idea of reversibility of changes is not a criterion for classifying changes as chemical or physical. Some changes cannot be reversed, like tearing paper. As students progress farther in chemistry, they will learn about equilibrium, which involves many chemical changes that are reversible. Dissolving an ionic substance is an example of a process that is not clearly chemical or physical since bonds are broken (Science: College Board Standards for College Success, 2009, page 125).**

### Future Application of Concepts

**High School:** Metalloids and pH calculations are introduced. Mixtures are classified as homogenous or heterogeneous. Trends in the properties and atomic structure of elements are related to the periodic table. The role of valence electrons in reactivity is explored, balanced chemical equations are written and stoichiometric problems are solved.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Use empirical evidence to construct an argument and defend a position.** | | | |
| Based on knowledge about the properties specific to certain types of material that can be used for packaging, design packaging (using various types of materials) for an egg that will allow it to drop from a considerable height without breaking. Organize and communicate resulting data in multiple formats. | Bubbles have characteristic behaviors based on the arrangement of the atoms that determine their molecular structure. Investigate bubbles and the bonds that are behind their structure (e.g., what gives them longevity, why their shape is spherical, is it possible to create square bubbles). Record and organize data to communicate findings in multiple ways (e.g., graphically, orally, pictorially). | Explain how the arrangement of atoms determines properties specific to a certain state of matter. | Match the properties of a state of matter with the picture of a sample representative of a specific state of matter. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- *Essential Science for Teachers* is a series of videos 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 videos 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 Videos** from the University of Nottingham contains short videos of all the elements. Videos include what the element looks like in elemental form, some of the reactions of the element and the uses for the element.

## COMMON MISCONCEPTIONS

- Essential Science for Teachers is a series of videos on demand produced by Annenberg. The segment **Physical Changes and Conservation of Matter** addresses student misconceptions in student interviews. Classroom activities to address these misconceptions are shown. While most of the content is applicable and primarily addresses the conservation of matter as it relates to change, note that the differentiation of change as "chemical" or "physical" is inappropriate.
- Essential Science for Teachers is a series of videos on demand produced by Annenberg. The segment **Chemical Changes and Conservation of Matter** addresses student misconceptions in student interviews. Classroom activities to address these misconceptions are shown. While most of the content is applicable and primarily addresses the conservation of matter as it relates to change, note that the differentiation of change as "chemical" or "physical" is inappropriate.
- Many students think that all acids are corrosive. Students can use litmus paper to test common foods to discover that many of the things they eat are acids.
- **Particles are misrepresented** and undifferentiated in situations involving elements, compounds, mixtures, solutions and substances. There is frequent disregard for particle conservation and orderliness when describing changes of matter.

BACK TO INDEX

BACK TO K-8 INDEX

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

**Erien, a new seventh-grade teacher**, demonstrates strategies to develop higher-level thinking skills in her students in **this video on demand** produced by Annenberg. While the content in this video is not directly related to the content statement, the strategies shown can be applied to any content.

**Dotty**, a veteran teacher, demonstrates strategies to incorporate technology and societal connections into her science lessons for seventh-grade students in this video on demand produced by Annenberg. While the content in this video is not directly related to the content statement, the strategies shown can be applied to any content.

**Rachel** demonstrates strategies to increase participation among girls and minority students in her science classroom in this video on demand produced by Annenberg. While the content in this video is not directly related to the content statement, the strategies shown can be applied to any content.

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

BACK TO INDEX
BACK TO K-8 INDEX

MODEL CURRICULUM GRADE 7

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Conservation of Mass and Energy**

This topic focuses on the empirical evidence for the arrangements of atoms on the Periodic Table of Elements, conservation of mass and energy, transformation and transfer of energy.

### 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.

**Note: Further discussion of energy transformation is addressed at the high school level.**

### CONTENT ELABORATION

**Prior Concepts Related to Energy Transfer**

**PreK-2:** Sound is produced by vibrating objects. The sun is the principal source of energy and affects the warming or cooling of Earth (ESS). Weather changes occur due to changes in energy (ESS). Plants get energy from sunlight and animals get energy from plants and other animals (LS).

**Grades 3-5:** Objects with energy have the ability to cause change. Energy can transfer from one location or object to another and can be transformed from one form to another (e.g., light, sound, heat, electrical energy, magnetic energy. Earth's resources can be used for energy (ESS). Sunlight is transformed by producers into energy that organisms can use and pass from organism to organism (LS).

**Grade 6:** There are two forms of energy: kinetic and potential. Energy can transform from one form to another. Thermal energy is due to random motion of the particles of a substance.

**Grade 7 Concepts:**

A system is separated from its surroundings by either a physical or mental boundary. An isolated system is one that does not interact with its surroundings. Matter and energy cannot get into or out of an isolated system. Most systems on Earth are open systems. Matter and energy can be transferred into or out of an open system. If energy appears to be gained or lost, it has just transformed or transferred into a different system. Examples of systems include ecosystems, the atmosphere, the hydrosphere, the solar system and the human body.

When energy transfers to a large system, it may be difficult to measure the effects of the added energy. Dissipated energy (energy that is transformed into thermal energy and released into the surroundings) is difficult or impossible to recapture. Some systems dissipate less energy than others, leaving more energy to use.

Investigation, testing and experimentation must be used to explore energy transfers and transformations. Observing the quantifiable energy changes in a virtual environment is recommended at this introductory level, as these can be difficult to measure accurately.

**Note 1: This content statement does not deal with radiation, convection and conduction. That is addressed in the seventh-grade Physical Science content statement.**

**Note 2: ESS grade 7 is connected to this content statement regarding thermal energy. Thermal energy is transformed as water changes state throughout the water cycle. Thermal energy transferred in the ocean and atmosphere contributes to the formation of currents, which influence global climate patterns (ESS grade 7). Middle school LS also is connected to this statement as it relates to the transfer and transformation of energy within ecosystems.**

**Future Application of Concepts**

**Grade 8:** Gravitational, chemical and elastic potential energy are explored.

**High School:** Waves are further explored as a method of transferring energy. Basic formulas are used to perform calculations with energy. Work is a method of and power is a rate of energy transfer.

BACK TO INDEX

BACK TO K-8 INDEX

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate 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.<br><br>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.<br><br>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 through the design of a machine.** | | | |
| Design and construct **a machine that performs a simple task in many steps**. Use materials that are lying around the classroom and the home.<br><br>Test the machine as each additional component is added.<br><br>Redesign to solve problems encountered during the testing.<br><br>Record any problems encountered as well as the changes made to the machine to overcome these problems. | | Use design software to make a labeled pictorial representation of the design.<br><br>Explain the solutions to problems encountered during testing.<br><br>Trace all the energy transformations that occur as the machine performs its task. | |

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| | **Investigate energy transformations for a skateboarder.** | | |
| | Plan and implement a scientific experiment to explore energy transformations for a skateboarder using the **Skate Park** simulation.<br><br>The program can track changes in different types of energy over time.<br><br>Analyze the data to determine patterns and trends.<br><br>Formulate a conclusion about energy transformations. Share the results with the class. | Summarize the experiment in writing.<br><br>Graphically represent the energy of the skateboarder during a run.<br><br>Use the results from different groups in the class to compare different designs to the energy graphs.<br><br>Support the conclusion with experimental evidence. | |
| | | Explain why the energy from a teaspoon of hot water appears to have disappeared as it is placed into a gallon of room temperature water. | Describe two ways that energy can leave a system so it may appear to disappear. |
| | | Explain where the energy of a swinging pendulum goes as it slows to an eventual stop. | Recognize that energy or matter cannot enter or leave a closed system. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **Career Corner** from EIA Kids has several articles that give information about different careers in energy.
- **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.

## COMMON MISCONCEPTIONS

Some students think that:

- **Energy is truly lost in many energy transformations**.
- *If energy is conserved, why are we running out of it?*
- Energy can be changed completely from one form to another (no energy losses).
- Things use up energy.
- Energy is a thing.
- The terms "energy" and "force" are interchangeable.
- Energy often disappears and is lost.
- Energy is a type of matter or substance that can flow like a liquid.
- Food and fuel are energy rather than sources of energy.
- **Transfer and Conversion of Energy** is one segment of *Science in Focus: Energy*, a series of videos on demand produced by Annenberg. This segment deals with energy transfers and transformations. The video series is designed to make teachers aware of common student misconceptions. While not all the concepts addressed are appropriate to be taught at this grade level, being aware of them can help avoid perpetuating common misconceptions.
- **Energy and Systems** is another segment of *Science in Focus: Energy*, a series of videos on demand produced by Annenberg. This segment deals with how energy that appears to be missing can be explained using the conservation of energy. The video series is designed to make teachers aware of common student misconceptions. While not all the concepts addressed are appropriate to be taught at this grade level, being aware of them can help avoid perpetuating common misconceptions.
- **Energy: Misconceptions and Teaching Models**, from the UK Department of Education, discusses different models of energy and the misconceptions that can be perpetuated by each model.

## DIVERSE LEARNERS

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

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

**Erien, a new seventh-grade teacher**, demonstrates strategies to develop higher-level thinking skills in her students in **this video on demand** produced by Annenberg. While the content in this video is not directly related to the content statement, the strategies shown can be applied to any content.

**Dotty**, a veteran teacher, demonstrates strategies to incorporate technology and societal connections into her science lessons for seventh-grade students in this video on demand produced by Annenberg. While the content in this video is not directly related to the content statement, the strategies shown can be applied to any content.

**Rachel** demonstrates strategies to increase participation among girls and minority students in her science classroom in this video on demand produced by Annenberg. While the content in this video is not directly related to the content statement, the strategies shown can be applied to any content.

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

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 7

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Conservation of Mass and Energy**

This topic focuses on the empirical evidence for the arrangements of atoms on the Periodic Table of Elements, conservation of mass and energy, transformation and transfer of energy.

### 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.

**Note 1: Energy transfers should be experiential and observable. This builds upon PS grade 4 and is directly connected to ESS grade 7 (thermal energy transfers in the hydrologic cycle).**

**Note 2: Electricity can be measured through current, voltage and resistance. In addition, renewable energy systems should be included (such as wind, geothermal, water or solar).**

**Note 3: The types of waves used within this topic include seismic, oceanic, sound and light. Seismic waves also are found in ESS grade 8.**

### CONTENT ELABORATION

**Prior Concepts Related to Energy Transfer**

**PreK-2:** Temperature changes are observed. The sun is the principal source of energy. It affects the temperature of Earth (ESS) and supplies life's energy (LS).

**Grades 3-5:** Objects with energy have the ability to cause change. Electrical, heat, light and sound energy are explored. Earth's resources can be used for energy (ESS). Energy is transferred and transformed by organisms in ecosystems (LS).

**Grade 6:** Energy is identified as kinetic or potential and can transform from one form to another (gravitational, potential, kinetic, electrical, magnetic, heat, light, sound). Density depends on the mass and volume of a substance. Thermal energy is related to the motion of particles.

**Grade 7 Concepts**

Mechanical energy is transferred when a force acts between objects that move one of the objects some distance with or against the force. The amount of energy transferred increases as the strength of the force and/or the distance covered by object increases. This energy transfer (work) stops when the objects no longer exert forces on each other.

Vibrations cause wave-like disturbances that transfer energy from one place to another. Mechanical waves require a material (medium) in which to travel. The medium moves temporarily as the energy passes through it, but returns to its original undisturbed position. Mechanical waves are classified as transverse or longitudinal (compression) depending on the direction of movement of the medium.

Waves can be described by their speed, wavelength, amplitude and frequency. The energy of a mechanical wave depends upon the material, decreases with increasing wavelength, and increases with amplitude. The pitch of a sound wave increases with the frequency and the loudness increases with amplitude. While light and other electromagnetic waves do not require a medium and can travel through a vacuum, they can travel through some media, such as clear glass. A wave travels at a constant speed through a particular material as long as it is uniform (e.g., for water waves, having the same depth). The speed of the wave depends on the nature of the material (e.g., waves travel faster through solids than gases). For a particular uniform medium, as the frequency (f) of the wave is increased, the wavelength ($\lambda$) of the wave is decreased. The mathematical representation is $v_{wave}=\lambda f$.

For grade 7, investigation 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.

BACK TO INDEX

BACK TO K-8 INDEX

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 simulations, 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.

**Note: The electromagnetic nature of electromagnetic radiation is not appropriate at this grade level nor are mathematical calculations of work or electricity.**

### Future Application of Concepts

**Grade 8:** Gravitational, chemical and elastic potential energy and seismic waves (ESS) are explored.

**High School:** Energy and work are explored mathematically.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate energy transformation by designing a candle wheel.** | | | |
| Design and construct a candle wheel that will turn a maximum number of times in one minute.<br><br>Test the designs from the class to determine the effectiveness of each one.<br><br>Anticipate two applications in which the concepts addressed in this design could be used in the real world. | Analyze data to determine patterns and trends between design and effectiveness.<br><br>Formulate a hypothesis about what design features are most effective. | Represent the design with a labeled picture constructed with design software.<br><br>Orally present the design to the class, explaining how energy is transferred at each step.<br><br>Compare the designs of different groups with the effectiveness of the designs.<br><br>Use a particle model of matter to explain how energy can be transformed through convection. | Recognize that thermal energy can be converted to mechanical energy. |
| **Investigate current in parallel and series circuits.** | | | |
| | Plan and implement a scientific experiment to investigate the amount of electric current flowing through different positions of both series and parallel circuits.<br><br>Analyze the data for series circuits to determine patterns and trends.<br><br>Formulate a conclusion that states what happens to the flow of electric current in a series circuit.<br><br>Analyze the data for parallel circuits to determine patterns and trends.<br><br>Formulate a conclusion that states what happens to the flow of electric current in a parallel circuit. | Organize and clearly represent the data from the experiment.<br><br>Compare the results for parallel and series circuits.<br><br>Support conclusions with evidence from the experiments.<br><br>Explain why the flow of current is the same at all parts of a series circuit. | Recognize that the flow of current is the same at all parts of a series circuit. |

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Investigate current in parallel and series circuits.** | | | |
| | | Explain how thermal energy can transfer from one object to another by conduction. | Recognize that electrical energy in a circuit can be transferred into kinetic, thermal, light, sound and/or magnetic energy. |
| | | Explain the motion of convection in liquids and gases. | Recall four different ways that energy can be transferred between two objects. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **Circuit Construction Kit (DC only)** is an **interactive simulation** that allows students to build and test circuits.
- Schools in Ohio's AEP electric service territory can participate in the AEP Foundations' **AEGIS program**. Designed to engage girls in the sciences, a team of middle school girls and their teacher spend three days building the Energy Bike, learn leadership skills and conduct a presentation of the bike at school or within their community. The bike is retained by the team's school for use in the school's district.
- **Solar Cookers** from PBS Kids gives a few ideas of design projects to convert radiant energy into heat energy.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- **Energy is a thing**.
- Energy is confined to some particular origin, such as what we get from food or what the electric company sells.
- The terms "energy" and "force" are interchangeable.
- From the non-scientific point of view, "work" is synonymous with "labor."
- It is hard to convince someone that more "work" is probably being done playing football for one hour than studying an hour for a quiz.
- **Hitting an object harder** changes the pitch of the sound produced.
- Human voice sounds are produced by a large number of vocal cords that all produce different sounds.
- Loudness and pitch of sounds are the same things.
- You can see and hear a distinct event at the same moment.
- Sounds can travel through empty space (a vacuum).
- Sounds cannot travel through liquids and solids.
- Sound waves are transverse waves (like water and light waves).
- Matter moves along with water waves as the waves move through a body of water.
- When waves interact with a solid surface, the waves are destroyed.
- In actual telephones, sounds (rather than electrical impulses) are carried through the wires.
- **Light is not considered to exist independently in space**.
- Light is not conceived as moving from one point to another with a finite speed.
- An object is seen whenever light shines on it, with no recognition that light must move between the object and the observer's eye.
- Light is not necessarily conserved. It may disappear or be intensified.
- Gamma rays, X-rays, ultraviolet light, visible light, infrared light, microwaves and radio waves are all very different entities.
- Light fills the room as water fills a bathtub.
- The mechanisms between the light, the object and the eye are not recognized to produce vision.
- **Current flows from a battery** (or other source of electricity) to a light bulb (or other item that consumes electricity), but not from the light bulb to the battery.
- Current flows out of both terminals of a dry cell or both connections in an electrical outlet.
- Current flows around a complete circuit, but it is used by objects like light bulbs so less current returns than leaves the source of the electricity.
- All the charges that make up an electrical current are initially contained in the battery or generator that is the source of the electricity.
- Electricity is produced in the wall socket.
- Charges change into light when a lamp is turned on.
- Wires are hollow like a water hose and charges move inside the hollow space.
- Batteries have electricity inside them.
- **Heat is a substance.**
- Heat is not energy.
- Heat and cold are different, rather than being opposite ends of continuum.
- Objects of different temperatures that are in constant contact with each other or in contact with air at a different temperature do not necessarily move toward the same temperature.
- Heat only travels upward.
- Heat rises.
- Cold is thought to be transferred rather than heat.
- Some materials may be thought to be intrinsically warm (blankets) or cold (metals).
- Objects that keep things warm, such as a sweater or mittens, may be thought to be sources of heat.
- There is often confusion between forms of energy and sources of energy.

BACK TO INDEX

BACK TO K-8 INDEX

- **Transfer and Conversion of Energy** is one segment of *Science in Focus: Energy*, a series of videos on demand produced by Annenberg. This segment deals with energy transfers and transformations. The video series is designed to make teachers aware of common student misconceptions. While, not all the concepts addressed are appropriate to be taught at this grade level, being aware of them can help avoid perpetuating common misconceptions.
- **Energy and Systems** is one segment of *Science in Focus: Energy*, a series of videos on demand produced by Annenberg. This segment deals with how energy that appears to be missing can be explained using the conservation of energy. The video series is designed to make teachers aware of common student misconceptions. While, not all the concepts addressed are appropriate to be taught at this grade level, being aware of them can help avoid perpetuating common misconceptions.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

**Erien, a new seventh-grade teacher**, demonstrates strategies to develop higher-level thinking skills in her students in **this video on demand** produced by Annenberg. While the content in this video is not directly related to the content statement, the strategies shown can be applied to any content.

**Dotty**, a veteran teacher, demonstrates strategies to incorporate technology and societal connections into her science lessons for seventh-grade students in this video on demand produced by Annenberg. While the content in this video is not directly related to the content statement, the strategies shown can be applied to any content.

**Rachel** demonstrates strategies to increase participation among girls and minority students in her science classroom in this video on demand produced by Annenberg. While the content in this video is not directly related to the content statement, the strategies shown can be applied to any content.

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

BACK TO INDEX
BACK TO K-8 INDEX

# Grade 8

## INTRODUCTION TO CONTENT STATEMENTS

### GRADE BAND THEME: ORDER AND ORGANIZATION

This theme focuses on helping students use scientific inquiry to discover patterns, trends, structures and relationships that may be described by simple principles. These principles are related to the properties or interactions within and between systems.

### SCIENCE INQUIRY AND APPLICATION

During the years of grades 5-8, all students must use the following scientific processes, with appropriate **laboratory safety techniques**, to construct their knowledge and understanding in all science content areas:

- Identify questions that can be answered through scientific investigations;
- Design and conduct a **scientific investigation**;
- Use appropriate mathematics, tools and techniques to gather data and information;
- Analyze and interpret data;
- Develop descriptions, models, explanations and predictions;
- Think critically and logically to connect evidence and explanations;
- Recognize and analyze alternative explanations and predictions; and
- Communicate scientific procedures and explanations.

### STRANDS

**Strand Connections:** Systems can be described and understood by analysis of the interaction of their components. Energy, forces and motion combine to change the physical features of the Earth. The changes of the physical Earth and the species that have lived on Earth are found in the rock record. For species to continue, reproduction must be successful.

| EARTH AND SPACE SCIENCE (ESS) | PHYSICAL SCIENCE (PS) | LIFE SCIENCE (LS) |
|---|---|---|
| **Topic: Physical Earth**<br>This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms. | **Topic: Forces and Motion**<br>This topic focuses on forces and motion within, on and around the Earth and within the universe. | **Topic: Species and Reproduction**<br>This topic focuses on continuation of the species. |
| **CONDENSED CONTENT STATEMENTS** | | |
| • The composition and properties of Earth's interior are identified by the behavior of seismic waves.<br>• Earth's crust consists of major and minor tectonic plates that move relative to each other.<br>• A combination of constructive and destructive geologic processes formed Earth's surface.<br>• Evidence of the dynamic changes of Earth's surface through time is found in the geologic record. | • Forces between objects act when the objects are in direct contact or when they are not touching.<br>• Forces have magnitude and direction.<br>• There are different types of potential energy. | • Diversity of species occurs through gradual processes over many generations. Fossil records provide evidence that changes have occurred in number and types of species.<br>• Reproduction is necessary for the continuation of every species.<br>• The characteristics of an organism are a result of inherited traits received from parent(s). |

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 8

# EARTH AND SPACE SCIENCE (ESS)

**Topic: Physical Earth**

This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.

### 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.

**Note: The thicknesses of each layer of Earth can vary and be transitional, rather than uniform and distinct as often depicted in textbooks.**

### CONTENT ELABORATION

**Prior Concepts Related to Earth's Interior**

**PreK-2:** Properties of materials can change due to heating or freezing. Forces change the motion of an object.

**Grades 3-5:** Matter exists in different states. Heating and cooling can change the state of matter. Heat is a form of energy. Energy can cause motion. Earth's surface is changed in many ways. Light changes direction when it moves from one medium to another; it can be reflected, refracted or absorbed.

**Grades 6-7:** Matter is made up of atoms. Igneous, metamorphic and sedimentary rocks form in different ways and in different environments. Magma from Earth's interior forms igneous rocks. Position and speed can be measured and graphed as a function of time. Matter and energy can be transferred through Earth's spheres. Energy can be transformed from one form to another. Thermal energy can be transferred through radiation, convection and conduction. Electromagnetic waves transfer energy when they interact with matter. Seismic and oceanic waves are found in PS grade 7.

**Grade 8 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.

Earth and other planets in the solar system formed as heavier elements coalesced in their centers. Planetary differentiation is a process in which more dense materials of a planet sink to the center, while less dense materials stay on the surface. A major period of planetary differentiation occurred approximately 4.6 billion years ago (College Board Standards for College Success, 2009).

In addition to the composition of Earth's interior, the history of the formation of Earth and the relationship of energy transfer, transformation and convection currents within the mantle and crust are essential in understanding sources of energy.

**Future Application of Concepts**

**High School:** Waves (all types), gravitational energy, energy transformation and transfer, and radioactivity are studied in greater detail. In addition, Earth's formation and the formation of the solar system are used as the formation of the universe is introduced.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design and build a model of an earthquake-resistant structure (e.g., bridge, building, home). Draw a blueprint of the plan or design. Provide data to validate the choice of design. Test results using a shake table or another quantifiable measuring device. | Design and build a simple seismograph that can measure movement of Earth's lithosphere. | Using real seismic data (wave velocities), create or interpret a cross section of Earth. Explain the change of appearance in the section as the rock type or consistency of the rock changes. | Identify the different composition and consistency of each layer of Earth's interior (inner and outer core, upper and lower mantle, crust). |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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. This is helpful for all students, but may be especially helpful for students that are more visual or have difficulty developing concepts from text.

## COMMON MISCONCEPTIONS

- A common student misconception is that only California or Alaska experiences earthquakes. Researching and examining actual seismic events that occur in Ohio or surrounding areas can dispel this misconception. The USGS provides seismic data for all 50 states, including real-time data, at **http://earthquake.usgs.gov/earthquakes/states/?old=top_states.html**.
- NASA lists common misconceptions for all ages about the sun and the Earth at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- NASA provides a list of overarching Earth Science questions that address many of the common misconceptions at this grade level. There are resources and information that help address questions that center on Earth Systems Science at **http://science.nasa.gov/big-questions/**.

BACK TO INDEX

BACK TO K-8 INDEX

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A Harvard case study on improving the teaching of science in real classrooms is available at **http://www.learner.org/resources/series21.html?pop=yes&pid=1050**. Nancy, an eighth-grade teacher, encourages students to work and think more on their own in her science class. This encourages true scientific inquiry and investigation at the student level.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 8

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Physical Earth**

This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Forces, Movement and Igneous Environments**

**PreK-2:** Properties of materials can change. Pushing and pulling can affect the motion of an object.

**Grades 3-5:** Forces change the motion of an object. Rocks have specific characteristics. Heat is a form of energy. Energy can be conserved. Earth's surface has specific characteristics. Heat results when materials rub against each other. Gravitational force and magnetism also are studied.

**Grades 6-7:** Rocks have characteristics that are related to the environment in which they form. Thermal energy is a measure of the motion of the atoms and molecules in a substance. Energy can be transformed, transferred and conserved. Thermal energy can be transferred through radiation, convection and conduction.

**Grade 8 Concepts**

The historical data related to the present plate tectonic theory must include continental "puzzle-like-fit" noticed as early as Magellan and by other mapmakers and explorers, paleontological data, paleoclimate data, paleomagnetic data, continental drift (Wegener), convection theory (Holmes) and sea floor spreading (Hess, Deitz). Contemporary data must be introduced, including seismic data, GPS/GIS data (documenting plate movement and rates of movement), robotic studies of the sea floor and further exploration of Earth's interior.

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).

Volcanic activity, earthquakes, tsunamis, geysers, hot springs, faults, oceanic vents, island arcs, hot spots and rift valleys should all be included in the identification of plates and plate boundaries. Plate boundary identification (converging, diverging, transform) must be based on the resulting features or events. The focus must be on the cause of plate movement, the type and direction of plate movement and the result of the plate movement, not on memorizing plate names.

**Future Application of Concepts**

**High School:** Thermal energy, gravitational energy, radioactive decay and energy transfer are studied. In the grades 11/12 Physical Geology course, further studies of plate tectonics, seismology and volcanism are found.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Research, design and construct a model of an earthquake-resistant structure (e.g., bridge, building, home). Draw a blueprint of the plan or design. Provide data to validate the choice of design. Test results using a shake table or another quantifiable measuring device with the class. | Research the most recent measurements of North America.<br><br>Using this data and the movement of North America throughout geologic time, predict where North America will be in 600 million years or more. Create a model to demonstrate that movement. | Differentiate between plate tectonics and continental drift. | Describe the general history of plate tectonics, including the early observations, discoveries and ideas that combined, that eventually lead to the modern theory of plate tectonics. |
| | 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.<br><br>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.<br><br>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. | Identify the standard geologic features or events that occur at each of the boundaries (e.g., oceanic trenches are formed at converging plate boundaries, oceanic ridges form at diverging plate boundaries). |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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.

## COMMON MISCONCEPTIONS

- Misconceptions regarding Earth Science, including those dealing with plate tectonics and Earth history, can be determined through a professional "gallery walk." Discussing the conclusions and findings can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

The Journal of Geoscience Education contains an article (Visual Abilities and Misconceptions about Plate Tectonics), Sept. 2005, outlining the use of student drawings to identify misconceptions at **http://d32ogoqmya1dw8.cloudfront.net/files/nagt/jge/abstracts/Sibley_v53p471.pdf**.

- NASA provides a list of overarching Earth Science questions that address many of the common misconceptions at this grade level. There are resources and information that help address questions that center on Earth Systems Science at **http://science.nasa.gov/big-questions/**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A Harvard case study on improving the teaching of science in real classrooms is available at **http://www.learner.org/resources/series21.html?pop=yes&pid=1050**. Nancy, an eighth-grade teacher, encourages students to work and think more on their own in her science class. This encourages true scientific inquiry and investigation at the student level.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 8

# EARTH AND SPACE SCIENCE (ESS)

**Topic: Physical Earth**

This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.

### 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.

**Note: The introduction of Earth's surface is found in ESS grade 4.**

### CONTENT ELABORATION

**Prior Concepts Related to Earth's Surface**

**PreK-2:** Water can be found in many forms and locations. Wind is moving air.

**Grades 3-5:** Characteristics of rocks and soil, weathering, deposition, erosion, landforms, mass wasting and weather events (e.g., flooding) are studied.

**Grades 6-7:** Igneous, metamorphic and sedimentary formation, interactions between Earth systems, and patterns of erosion and deposition are studied.

**Grade 8 Concepts**

The interactions between the hydrosphere and lithosphere are studied as they relate to erosional events (e.g., flooding, mass wasting). The characteristics of rocks and soil, the climate, location, topography and geologic process are studied.

Distinguishing between major geologic processes (e.g., tectonic activity, erosion, deposition) and the resulting feature on the surface of Earth is the focus of this content statement. It is important to build on what was included in the elementary grades (recognizing features), enabling students to describe conditions for formation. Topographic, physical and aerial maps, cross-sections, field trips and virtual settings are methods of demonstrating the structure and formation of each type of feature. The use of technology (remote sensing, satellite data, LANDSAT) can be used to access real-time photographs and graphics related to landforms and features.

Factors that affect the patterns and features associated with streams and floodplains (e.g., discharge rates, gradients, velocity, erosion, deposition), glaciers (e.g., moraines, outwash, tills, erratic, kettles, eskers), tectonic activity (should include the features listed in the content statement above), coastlines, flooding and deserts should be studied.

**Future Application of Concepts**

**High School:** Gravitational forces and movement of matter are explored. In the grades 11/12 Physical Geology course, glaciation, sedimentation, stream evolution, seismology, volcanics, bathymetry and further information about weathering, erosion and deposition are included.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Research a specific area with active geologic processes or events. Develop a plan to harness the available energy (e.g., heat from magma, water movement) from the process. Build a working model using specific data from the location, including the geologic record, that can be used to evaluate the efficiency of the type of energy chosen. Present findings, recommendations and model to the class. | Research the most recent measurements of North America. Using this data and the movement of North America throughout geologic time, predict where North America will be in 600 million years or more. Create a model to demonstrate that movement. | Put together a **model** of karst topography enabling a 3-D view of a cave or sinkhole. Research the processes that must occur to form karst topography. Communicate the research in writing or orally. | Identify examples of destructive geologic processes (e.g., flooding, mass wasting, volcanic activity, glacial movement, earthquakes, tsunamis. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- 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.

BACK TO INDEX

BACK TO K-8 INDEX

## COMMON MISCONCEPTIONS

- NASA provides a list of overarching Earth Science questions that address many of the common misconceptions at this grade level. There are resources and information that help address questions that center on Earth Systems Science at **http://science.nasa.gov/big-questions/**.
- NSTA provides recommendations for specific publications that are designed to address strategy in the K-8 classroom to support teaching science to all students in the classroom. Helpful in starting to work with inquiry to reach and engage all students, the recommendations can be found at **http://www.nsta.org/recommends/ViewProduct.aspx?ProductID=18466**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A Harvard case study on improving the teaching of science in real classrooms is available at **http://www.learner.org/resources/series21.html?pop=yes&pid=1050**. Nancy, an eighth-grade teacher, encourages students to work and think more on their own in her science class. This encourages true scientific inquiry and investigation at the student level.

BACK TO INDEX
BACK TO K-8 INDEX

MODEL CURRICULUM GRADE 8

## EARTH AND SPACE SCIENCE (ESS)

**Topic: Physical Earth**

This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.

### 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.

**Note: Environmental and climate conditions also can be documented through the cryosphere as seen through ice cores.**

### CONTENT ELABORATION

**Prior Concepts Related to Rocks and Fossils**

**PreK-2:** Some living things that once lived on Earth no longer exist because their needs were not met.

**Grades 3-5:** Rocks have characteristics and form in different ways. Earth's surface changes. 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 living today. Rocks can change size and shape due to weathering, water and wind. Ice can physically remove and carry rock, soil and sediment.

**Grades 6-7:** Igneous, metamorphic and sedimentary rocks form in different ways. Each type of rock can provide information about the environment in which it was formed.

**Grade 8 Concepts**

The representation of the age of the Earth must include a graphic demonstration of the immensity of geologic time, as this is a very difficult concept to grasp. The different methods used to determine the age of the Earth are an important factor in this concept. In elementary grades, fossils are used to compare what once lived to what lives now, but the concept of Earth's age and the age of the fossils were not included (the concept of billions or millions of years was not age-appropriate). In grade 8, the concept of index fossils is a way to build toward understanding relative dating. Superposition, crosscutting relationships and index fossils play an important role in determining relative age. Radiometric dating plays an important role in absolute age. The inclusion of new advances and studies (mainly due to developing technological advances) is important in learning about the geologic record.

Uniformitarianism can be an important key in understanding how scientists have interpreted the environmental conditions that existed throughout Earth's history. Fossil evidence also can indicate specific environments and climate conditions that help interpret the geologic record. Relating Earth's climate history to present-day climate issues should include evidence from ice core sampling as well as evidence from the geologic record.

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. Analyzing and interpreting the data to draw conclusions about geologic history is an important part of this content statement.

**Note: This content is closely connected to LS grade 8 content pertaining to diversity of species as documented in the fossil record, tracing changes evident in the fossil record and relating this content to evolution.**

**Future Application of Concepts**

**High School:** The age of Earth is further explored through learning about the evolution and extinction of species throughout Earth's history. In grades 11/12 Physical Geology, the interpretations of sections of the rock record and geologic time periods are explored.

BACK TO INDEX

BACK TO K-8 INDEX

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Research a specific area with active geologic processes or events. Evaluate the different possible types of energy available at the event or location. Develop a plan to harness the available energy (e.g., heat from magma, water movement) from the process. Build a working model using specific data from the location, including the geologic record. Present findings, recommendations and model to the class. | 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. | Describe the methods used by scientists to determine that the age of Earth is approximately 4.6 billion years. |
| | | | Recognize the immensity of the geologic time scale. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The **USGS** provides helpful background data to understand the relationship between the structure of Earth, the history of Earth and plate tectonics. Students often struggle with the immense scale of Earth's history, so using relative and absolute time data to construct timelines can be helpful. 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.

## COMMON MISCONCEPTIONS

- Understanding the age of the Earth (4.6 billion years) can be difficult to grasp. This **activity** helps demonstrate the time scale in a visual and active way using a football field as the "scale." The activity can be modified to include important events and fossils for North America or Ohio to generate student interest.
- NASA lists common misconceptions for all ages about the sun and the Earth at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- Students may have misinformation and misconceptions that pertain to climate change. To address this, it is important to provide evidence of climate change throughout Earth's history and current data to document temperature changes (surface and oceanic). Data and other resources to help with teaching climate change can be found on EPA's website at **http://www.epa.gov/climatechange/index.html**.
- NASA provides a list of overarching Earth Science questions that address many of the common misconceptions at this grade level. There are resources and information that help address questions that center on Earth Systems Science at **http://science.nasa.gov/big-questions/**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A Harvard case study on improving the teaching of science in real classrooms is available at **http://www.learner.org/resources/series21.html?pop=yes&pid=1050**. Nancy, an eighth-grade teacher, encourages students to work and think more on their own in her science class. This encourages true scientific inquiry and investigation at the student level.

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Research cloning in the food industry. Select one practice and determine whether or not it is an environmentally healthy practice. Justify your position with scientific evidence. | Examine offspring in plants that are produced sexually. Note and record variations that appear. Determine how the variations may help an organism to survive if the environment should change (e.g., warmer or cooler temperatures, increase or decrease in precipitation). | Explain why genetic variation is a survival advantage. | Describe the features of sexual and asexual reproduction related to the transfer of genetic information from parent to offspring. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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.
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment.
- The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In *Bottleneck Genes*, students simulate the gene-pool analysis of an animal population and all the factors that affect it, including genetic diversity, environmental change, and limiting factors.

## COMMON MISCONCEPTIONS

- **Weber State University** provides a list for misconceptions in biology. Scroll down to Standard IV to address misconceptions about reproduction.

## DIVERSE LEARNERS

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

- Many *Project Wild* activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. In *Bottleneck Genes*, students simulate the gene-pool analysis of an animal population and all the factors that affect it, including genetic diversity, environmental change, and limiting factors.

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

A Harvard case study on improving the teaching of science in real classrooms is available at **http://www.learner.org/resources/series21.html?pop=yes&pid=1050**. Nancy, an eighth-grade teacher, encourages students to work and think more on their own in her science class. This encourages true scientific inquiry and investigation at the student level.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 8

# LIFE SCIENCE (LS)

**Topic: Species and Reproduction**

This topic focuses on continuation of the species.

### 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.

**Note: Population genetics and the ability to use statistical mathematics to predict changes in a gene pool are reserved for grade 10.**

### CONTENT ELABORATION

**Prior Concepts Related to Species and Reproduction**

**PreK-2:** Living things have physical traits that enable them to live in different environments. Some kinds of individuals that once lived on Earth have completely disappeared, although they may be something like others that are alive today.

**Grades 3-5:** Fossils provide a point of comparison between the types of organisms that lived long ago and those existing today.

**Grades 6-7:** In any particular biome, the number, growth and survival of organisms and populations depend on biotic and abiotic conditions.

**Grade 8 Concepts**

The fossil record documents the variation in a species that may have resulted from changes in the environment. The fossil record is contained within the geologic record (ESS grade 8). Combining data from the geologic record and the fossil record, **Earth's living history** can be interpreted. Data and evidence from the fossil record must be used to develop further the concepts of extinction, biodiversity and the **diversity of species**.

Diversity can result from sexual reproduction. The sorting and combination of genes results in different genetic combinations, which allow offspring to be similar to, yet different from, their parents and each other. (This statement must be connected to the grade 8 Life Science content statement on reproduction and Mendelian Genetics.) These variations may allow for survival of individuals when the environment changes. Diversity in a species increases the likelihood that some individuals will have characteristics suitable to survive under changed conditions.

Evidence from geologic and fossil records can be used to infer what the environment was like at the time of deposition, The variations that exist in organisms can accumulate over many generations, so organisms can be very different in appearance and behavior from their distant ancestors.

**Note 1: Molecular clocks are not appropriate at this grade level.**

**Note 2: The term "transitional form" should be used to describe parts of the fossil record that are incomplete.**

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Research a genetically modified organism (e.g., Bt corn) and make a<br><br>Recommendation whether or not it is harmful to the environment. Provide peer-reviewed scientific evidence to support your answer. Evaluate the validity of the scientific claims made by both proponents and opponents of using genetically modified organisms for food. | Conduct a field study on a specific population of plants or animals in a local area. Examine members of that population and record variations in physical characteristics that can be seen (e.g., height, coloration, number of flowers). Predict which traits are more beneficial for survival in the population's current environment. Predict what variations may result in higher survival rates should the environment change (e.g., became warmer, colder, windy). | Create a timeline that illustrates the relative ages of fossils of a particular organism in sedimentary rock layers. | Describe how to determine the relative age of fossils found in sedimentary rock. |
| | | Graph data that indicates how the biodiversity in a particular biome or continent have changed over time. | |
| | | Examine organisms that are found in a variety of environments and others that have very specific habitats. Compare and contrast the ability of an organism to survive under different environmental conditions. | |
| | | Explain why variation within a population can be advantageous for a population of organisms. | |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The Annenberg Media series *Essential Science for Teachers:* **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.
- The Annenberg Media series *Essential Science for Teachers:* **Life Science: Session 6** provides information about how children can learn about the variations of living things that lead to evolution. It focuses on the development of a species.
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In *Bottleneck Genes*, students simulate the gene-pool analysis of an animal population and all the factors that affect it, including genetic diversity, environmental change, and limiting factors. In *Here Today, Gone Tomorrow*, students explore endangered species and the reasons why they are endangered.
- **Guide to Using Animals in the Classroom** by the Ohio Department of Natural Resources provides guidance, explains legally which organisms may be collected and limited advice on use of animals in the classroom.
- ODNR-Division of Wildlife's **A to Z Species Guide** has photos, information, tracks and sounds of Ohio's wild animals.

## COMMON MISCONCEPTIONS

- **AAAS' Benchmarks 2061 Online, Chapter 15**, 5f, *Evolution of Life*, states many students believe that environmental conditions are responsible for changes in traits or that organisms develop new traits because they need them to survive.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A Harvard case study on improving the teaching of science in real classrooms is available at **http://www.learner.org/resources/series21.html?pop=yes&pid=1050**. Nancy, an eighth-grade teacher, encourages students to work and think more on their own in her science class. This encourages true scientific inquiry and investigation at the student level.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 8

## LIFE SCIENCE (LS)

**Topic: Species and Reproduction**

This topic focuses on continuation of the species.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Species and Reproduction**

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

**Grades 6-7:** Modern Cell Theory states cells come from pre-existing cells.

**Grade 8 Concepts**

An individual organism does not live forever. Reproduction is necessary for the continuation of every species. Most organisms reproduce either sexually or asexually. Some organisms are capable of both. In asexual reproduction, all genes come from a single parent, which usually means the offspring are genetically identical to their parent, allowing genetic continuity. Mitosis was investigated in grade 6. The end products of mitotic and meiotic cell divisions are compared as they relate to asexual and sexual reproduction. It is important that both mitosis and meiosis are addressed in preparation for future study of Mendelian genetics and embryology.

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.

**Future Application of Concepts**

**High School:** The details and importance of gamete formation are studied.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Research cloning in the food industry. Select one practice and determine whether or not it is an environmentally healthy practice. Justify your position with scientific evidence. | Examine offspring in plants that are produced sexually. Note and record variations that appear. Determine how the variations may help an organism to survive if the environment should change (e.g., warmer or cooler temperatures, increase or decrease in precipitation). | Explain why genetic variation is a survival advantage. | Describe the features of sexual and asexual reproduction related to the transfer of genetic information from parent to offspring. |

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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.
- *Project Wild* was developed through a joint effort of the Western Association of Fish and Wildlife Agencies and the Council for Environmental Education. This program helps students learn basic concepts about wild animals, their needs and importance and their relationships to people and the environment. The activity guides are available to educators free of charge when they attend a workshop. Information about upcoming workshops are available on the **ODNR Website**. In *Bottleneck Genes*, students simulate the gene-pool analysis of an animal population and all the factors that affect it, including genetic diversity, environmental change, and limiting factors.

## COMMON MISCONCEPTIONS

- **Weber State University** provides a list for misconceptions in biology. Scroll down to Standard IV to address misconceptions about reproduction.

## DIVERSE LEARNERS

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

- Many *Project Wild* activities feature Universal Design for Learning principals by providing multiple means of concept representation; means of physically interacting with materials; and multiple means of engagement, including collaboration and communication. In *Bottleneck Genes*, students simulate the gene-pool analysis of an animal population and all the factors that affect it, including genetic diversity, environmental change, and limiting factors.

BACK TO INDEX

BACK TO K-8 INDEX

## CLASSROOM PORTALS

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

A Harvard case study on improving the teaching of science in real classrooms is available at **http://www.learner.org/resources/series21.html?pop=yes&pid=1050**. Nancy, an eighth-grade teacher, encourages students to work and think more on their own in her science class. This encourages true scientific inquiry and investigation at the student level.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 8

## LIFE SCIENCE (LS)

**Topic: Species and Reproduction**

This topic focuses on continuation of the species.

### CONTENT STATEMENT

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

Expression of all traits is determined by genes and environmental factors to varying degrees. Many genes influence more than one trait, and many traits are influenced by more than one gene.

During reproduction, genetic information (DNA) is transmitted between parent and offspring. In asexual reproduction, the lone parent contributes DNA to the offspring. In sexual reproduction, both parents contribute DNA to the offspring.

**Note 1: The focus should be the link between DNA and traits without being explicit about the mechanisms involved.**

**Note 2: The ways in which bacteria reproduce is beyond the scope of this content statement.**

**Note 3: The molecular structure of DNA is not appropriate at this grade level.**

### CONTENT ELABORATION

**Prior Concepts Related to Species and Reproduction**

**PreK-2:** Offspring tend to look their parents.

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

**Grades 6-7:** Modern Cell Theory states cells come from pre-existing cells.

**Grade 8 Concepts**

The traits of one or two parents are passed on to the next generation through reproduction. Traits are determined by instructions encoded in deoxyribonucleic acid (DNA), which forms genes. Genes have different forms called alleles. Introduce the principles of Mendelian genetics by reviewing Mendel's work. Mendel's two laws provide the theoretical base for future study of modern genetics. Mendel's first law, the Law of Segregation, and his second law, the Law of Independent Assortment, should be demonstrated and illustrated in a variety of organisms. The concepts of dominant and recessive genes are appropriate at this grade level. Codominant traits such as roan color in horses and cows may be useful to provide further validation of the theory and to help dispel some misconceptions. Pedigree analysis is appropriate for this grade level when limited to dominant, recessive or codominance of one trait. The Law of Independent Assortment should only be explored in simple cases of dominance and recessive traits. Chi-square and dihybrid crosses are reserved for high school.

Conduct a long-term investigation to analyze and compare characteristics passed on from parent to offspring through sexual and asexual reproduction. Ask questions about the phenotypes that appear in the resulting generations and what they infer about genotypes of the offspring.

**Note: Incomplete dominance is not suggested for this grade level to help avoid the misconception of "blending of traits." Codominance is encouraged because both traits are expressed in the resulting offspring.**

**Future Application of Concepts**

**High School:** The details and importance of gamete formation, the structure of DNA and modern genetics are studied.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Designer dogs are developed to meet human needs. Investigate a number of breeds and explain the benefits and drawbacks of mixing the breeds. Make sure to examine several generations of dogs to determine the stability of the resulting hybrid. | Design and implement an investigation to predict the genotype and phenotypes of offspring between plants of known heritage (e.g., Wisconsin Fast Plants™) | Compare the exchange of genetic information during sexual and asexual reproduction. | Describe how genes, chromosomes and inherited traits are connected. |
| | | Given the genetic characteristics of the parents, use a Punnett square to predict the genetic outcome of the offspring produced. | Describe the characteristics and transfer of dominant and recessive traits. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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.
- **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.

### Career Connection

Students will research the roles of careers related to genetics, such as:

- Geneticists: expertise in the study of genetics.
- Veterinarian and Vet Techs: managing the health and wellness of animals, understanding animal reproductive behaviors and patterns.
- Biologists: study plants and animals and their environments.
- Medical and Animal Scientists: develop and improve products by conducting research and experiments.

Students will conduct career interviews, through a workplace visit or by telephone, to gather information that describes the real-work context of this classroom content.

## COMMON MISCONCEPTIONS

- **AAAS' Benchmarks 2061 Online, Chapter 15**, 5b, *Heredity*, highlights that students think sexual reproduction results in traits being inherited from only one parent (e.g., the mother or same-sex parent). They also may believe that there is a "blending of characteristics" in offspring.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

A Harvard case study on improving the teaching of science in real classrooms is available at **http://www.learner.org/resources/series21.html?pop=yes&pid=1050**. Nancy, an eighth-grade teacher, encourages students to work and think more on their own in her science class. This encourages true scientific inquiry and investigation at the student level.

BACK TO INDEX

BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 8

## PHYSICAL SCIENCE (PS)

**Topic: Forces and Motion**

This topic focuses on forces and motion within, on and around the Earth and within the universe.

### CONTENT STATEMENT

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

Magnetic, electrical and gravitational forces can act at a distance.

**Note: Direct contact forces were addressed in the elementary grades.**

### CONTENT ELABORATION

**Prior Concepts Related to Forces**

**PreK-2:** Forces are pushes and pulls. Forces are required to change the motion of an object. Magnetic, gravitational and electrical forces act without touching.

**Grades 3-5:** The amount of change in movement of an object is based on the mass* of the object and the amount of force exerted. The speed of an object is defined and calculated.

**Grades 6-7:** 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.

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

**Grade 8 Concepts**

A field model can be used to explain how two objects can exert forces on each other without touching. An object is thought to have a region of influence, called a field, surrounding it. When a second object with an appropriate property is placed in this region, the field exerts a force on and can cause changes in the motion of the object.

Electric fields exist around objects with charge. If a second object with charge is placed in the field, the two objects experience electric forces that can attract or repel them, depending on the charges involved. Electric force weakens rapidly with increasing distance.

Magnetic fields exist around magnetic objects. If a second magnetic object is placed in the field, the two objects experience magnetic forces that can attract or repel them, depending on the objects involved. Magnetic force weakens rapidly with increasing distance. Magnetic field lines can be seen when iron filings are sprinkled around a magnet.

Gravitational fields exist around objects with mass. If a second object with mass is placed in the field, the two objects experience attractive gravitational forces toward each other. Gravitational force weakens rapidly with increasing distance.

Every object exerts a gravitational force on every other object with mass. These forces are hard to detect unless at least one of the objects is very massive (e.g., sun, planets). The gravitational force increases with the mass of the objects, decreases rapidly with increasing distance and points toward the center of objects. Weight is gravitational force and is often confused with mass. Weight is proportional to mass, but depends upon the gravitational field at a particular location. An object will have the same mass when it is on the moon as it does on Earth. However, the weight (force of gravity) will be different at these two locations.

Electricity is related to magnetism. In some circumstances, magnetic fields can produce electrical currents in conductors. Electric currents produce magnetic fields. Electromagnets are temporary magnets that lose their magnetism when the electric current is turned off. Building an electromagnet to investigate magnetic properties and fields can demonstrate this concept.

BACK TO INDEX

BACK TO K-8 INDEX

Generators convert mechanical energy into electrical energy and are used to produce electrical energy in power plants. Electric motors convert electrical energy into mechanical energy. Motors are in blenders and washing machines. Both motors and generators have magnets (or electromagnets) and a coil of wire that creates its own magnetic field when an electric current flows through it.

**Note 1: Magnetic poles are often confused with electric charges. It is important to emphasize the differences.**

**Note 2: Mathematics is not used to describe fields at this level.**

**Note 3: This content statement involves a basic introduction to the field model. Details about the field model are not required other than the idea that a field is a concept that is used to understand forces that act at a distance.**

### Future Application of Concepts

**High School:** The strength of the force between two charges is calculated using Coulomb's Law. Electromagnetic induction is applied to generator and motors. DC circuits are studied.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| | **Investigate 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.<br><br>Analyze the data to determine patterns and trends.<br><br>Formulate a conclusion about the relationship. | Represent the data graphically.<br><br>Support the conclusion with evidence from the simulation. | Recognize that the electrical force increases as the electrical charges increase.<br><br>Recognize that the electrical force decreases when the distance between the charges increases. |
| Design and build a prototype of a device that can be attached to a crane to lift and move cars made of iron. The force of attraction lifting the car must be able to be released to deposit the cars in the desired location.<br><br>Test the designs of different groups in the class to determine which design can lift the largest mass. | | Use the field model to explain why an apple will fall toward Earth. | Given a simple interaction between two objects that are not touching (e.g., a ball falling to the ground, a magnet and a steel cabinet, hair and a brush experiencing static), identify the objects involved in the interaction and give the direction of the force on each object.<br><br>Given a simple contact interaction between two objects, identify the objects involved and give the direction of the force on each object. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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.
- Hand-cranked radios or cell-phone chargers are examples of items that include generators.

## COMMON MISCONCEPTIONS

- **Only animate objects can exert a force.**
- Force is a property of an object.
- An object has force and when it runs out of force, it stops moving.
- Large objects exert a greater force than small objects.
- There is no gravity in space.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

**Audrey**, teaching eighth-grade science for the first time, demonstrates strategies to empower students to take responsibility for their own learning in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

**Pat** demonstrates strategies to ensure that the science inquiry activities she does with her students lead to higher-level thinking and deeper understanding in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

**Nancy** demonstrates strategies to ensure that the science inquiry activities she does with her students lead to higher-level thinking and deeper understanding in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

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

BACK TO INDEX
BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 8

# PHYSICAL SCIENCE (PS)

**Topic: Forces and Motion**

This topic focuses on forces and motion within, on and around the Earth and within the universe.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Forces**

**PreK-2:** Forces are introduced as pushes and pulls that can change the motion of objects. Forces are required to change the motion of an object. Greater force on a given object results in greater change of motion.

**Grades 3-5:** The amount of change in movement of an object is based on the mass* of the object and the amount of force exerted.

**Grades 6-7:** 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.

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

**Grade 8 Concepts**

Motion can be described in different ways by different observers (e.g., a pencil held in someone's hand may appear to be at rest, but to an observer in a car speeding by, the pencil may appear to be moving backward).

A force is described by its strength (magnitude) and in what direction it is acting. Many forces can act on a single object simultaneously. The forces acting on an object can be represented by arrows drawn on an isolated picture of the object (a force diagram). The direction of each arrow shows the direction of push or pull. When many forces act on an object, their combined effect is what influences the motion of that object. The sum of all the forces acting on an object depends not only on how strong the forces are, but also in what directions they act. Forces can cancel to a net force of zero if they are equal in strength and act in opposite directions. Such forces are said to be balanced. If all forces are balanced by equal forces in the opposite direction, the object will maintain its current motion (both speed and direction). This means if the object is stationary, it will remain stationary. If the object is moving, it will continue moving in the same direction and at the same speed. Such qualitative, intuitive understandings and descriptions of inertia must be developed through inquiry activities.

Kinetic friction is a force that occurs when two objects in contact interact by sliding past one another. Drag is a force that opposes the motion of an object when an object moves through a fluid (e.g., gas, liquid). Kinetic friction and drag affect the motion of objects and may even cause moving objects to slow to a stop unless another force is exerted in the direction of motion. This phenomenon leads to the misconception that objects require a sustained force to continue moving. Experimentation with objects that have limited friction (e.g., a puck on an air hockey table, dry ice on a surface) can address the misconception that objects with a net force of zero naturally slow down.

BACK TO INDEX

BACK TO K-8 INDEX

If the forces are not balanced, the object's motion will change, either by speeding up, slowing down or changing direction. Qualitative, intuitive understandings of the influence of unbalanced forces on objects must be developed through inquiry investigations.

**Note 1: The concept of fields for objects that exert forces without touching is introduced at this grade level.**

**Note 2: The content description states that there will be acceleration when "the net force is greater than zero." When positive and negative values are used to represent the direction of forces, this statement will need to be expanded. Any nonzero net force, including a negative net force, also may result in a change in speed or direction (acceleration).**

### Future Application of Concepts

**High School:** Newton's second law will be developed quantitatively and situations will be explored mathematically.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO K-8 INDEX

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| Design and build a simple model to demonstrate the benefits of seatbelts using Newton's first law of motion. Use the models to compare the effectiveness of shoulder and lap belts vs. lap belts alone. | Plan and implement a scientific experiment to determine how two opposing forces affect the change in motion of a system when two opposing weights are connected by a string hanging over a pulley. | Explain how the force of gravity can be acting on a book at rest on a table and yet the book does not change its motion. | Recognize that an unbalanced force acting on an object changes that object's speed and/or direction. |
| | Implement a scientific investigation to determine what type of force is needed to get a moving puck on an air hockey table to slow down, speed up and move in a circle.<br><br>**Note: Using a broom on a bowling ball to trace the lines and circles on the gymnasium floor could be substituted if an air hockey table is not available.** | Explain why a heavy cabinet does not change its motion, even though a strong pushing force is applied. | Recognize that free fall results from the gravitational attraction between Earth and an object. |
| | | Predict the combined effect of several forces on an object at rest or an object moving in a straight line (e.g., speed up, slow down, turn left, turn right). | Recall that an unbalanced force acting on an object changes that object's speed and/or direction. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Use balloon cars, hover pucks and air hockey tables with students to explore motion that is not affected by a great deal of friction.
- **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.

## COMMON MISCONCEPTIONS

- **The only natural motion is for an object to be at rest.**
- If an object is at rest, no forces are acting on the object.
- Only animate objects can exert a force. Thus, if an object is at rest on a table, no forces are acting on it.
- Force is a property of an object. An object has force and when it runs out of force, it stops moving.
- A force is needed to keep an object moving with a constant speed. Students do not realize that gravity and friction are forces.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

**Audrey**, teaching eighth-grade science for the first time, demonstrates strategies to empower students to take responsibility for their own learning in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

**Pat** demonstrates strategies to ensure that the science inquiry activities she does with her students lead to higher-level thinking and deeper understanding in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

**Nancy** demonstrates strategies to ensure that the science inquiry activities she does with her students lead to higher-level thinking and deeper understanding in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

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

BACK TO INDEX
BACK TO K-8 INDEX

## MODEL CURRICULUM GRADE 8

## PHYSICAL SCIENCE (PS)

**Topic: Forces and Motion**

This topic focuses on forces and motion within, on and around the Earth and within the universe.

### 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.

### CONTENT ELABORATION

**Prior Concepts Related to Energy**

**PreK-2:** The sun is the principal source of energy (ESS). Plants get energy from sunlight (LS).

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

**Grades 6-7:** All matter is composed of atoms. Each substance has its own unique, unchanging composition of type and number of atoms. There are two general categories of energy: kinetic and potential. Energy can be transformed or transferred, but is never lost. The thermal energy of water changes during the water cycle (ESS). Thermal energy transfers in the ocean and the atmosphere contribute to the formation of currents that influence global climate patterns (ESS). Plants transform light energy into the potential energy contained in organic molecules, which can then be transformed into thermal and other forms of energy when the molecules are broken down (LS).

**Grade 8 Concepts:**

Gravitational potential energy is associated with the mass of an object and its height above a reference point (e.g., above ground level, above floor level). A change in the height of an object is evidence that the gravitational potential energy has changed.

Elastic potential energy is associated with how much an elastic object has been stretched or compressed and how difficult such a compression or stretch is. A change in the amount of compression or stretch of an elastic object is evidence that the elastic potential energy has changed.

Chemical potential energy is associated with the position and arrangement of the atoms within substances. Rearranging atoms into new positions to form new substances (chemical reaction) is evidence that the chemical potential energy has most likely changed. The energy transferred when a chemical system undergoes a reaction is often thermal energy.

Electrical potential energy is associated with the position of electrically charged objects relative to each other and the amount of charge they have. A change in the position of charged particles relative to each other is evidence of a change in electrical potential energy.

Magnetic potential energy is associated with the position of magnetic objects relative to each other.

BACK TO INDEX

BACK TO K-8 INDEX

The different types of potential energy must be explored through experimentation and investigation that include the relationship of energy transfer and springs, magnets or static electricity.

**Note: Potential energy is often taught as "stored" energy. If the word "stored" means that it is kept by the object and not given away to another object, then kinetic energy also can be classified as "stored" energy. A rocket moving at constant speed through space has kinetic energy and is not transferring any of this energy to another object.**

### Future Application of Concepts

**High School:** Gravitational potential energy will be calculated for objects at varying heights and kinetic energy will be calculated for moving objects. Conservation of energy will be explored mathematically. Elastic potential energy will be calculated for different systems. Electric potential and electric potential energy will be introduced.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| **Explore potential energy in the design of a pinball machine.** | | | |
| Design a way to give a steel marble the most possible potential energy in a pinball machine before it is launched. | With the class, plan a scientific investigation to test and compare the amount of energy of the designs of the different groups in the class.<br>Implement the test on the class designs.<br>Formulate a hypothesis about which design features provide the marble with the most potential energy. | Compare the design features to determine what features affect the amount of potential energy given to the ball. | |

BACK TO INDEX

BACK TO K-8 INDEX

| DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS | DEMONSTRATING SCIENCE KNOWLEDGE | INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS | RECALLING ACCURATE SCIENCE |
|---|---|---|---|
| | **Investigate the relationship between height and gravitational potential energy.** | | |
| | Plan and implement a scientific experiment to determine the relationship between the height of a metal sphere and the amount of change it can make to sand that is held in a container. Determine how to quantify the changes to the sand.<br><br>Formulate a conclusion about how the height of an object is related to its potential energy. | Represent the data graphically.<br><br>Support the conclusion with data from the experiment. | Recognize that gravitational potential energy increases with height. |
| | **Investigate the relationship between mass and gravitational potential energy.** | | |
| | Plan and implement a scientific experiment to determine the relationship between the mass of a metal sphere and the amount of change it can make to sand that is held in a container. Determine how to quantify the changes to the sand.<br><br>Formulate a conclusion about how the mass of an object is related to its potential energy. | Represent the data graphically.<br><br>Support the conclusion with data from the experiment. | Recognize that gravitational potential energy increases with mass. |
| | | Use an energy bar graph to show different types of energy (gravitational potential, elastic potential, kinetic energy) for a stretched rubber band that is launched straight up into the air. Show bar graphs for five different positions: before launching, ¼ the way up, ½ the way up, ¾ the way up, and at the top of its path. | Identify five different types of potential energy. |

BACK TO INDEX

BACK TO K-8 INDEX

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **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.

## COMMON MISCONCEPTIONS

- **An object at rest has no energy.**
- The only type of potential energy is gravitational.
- Gravitational potential energy depends only on the height of an object.
- The terms "energy" and "force" are interchangeable.
- **Energy is a thing, an object or something that is tangible.**

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

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

**Audrey**, teaching eighth-grade science for the first time, demonstrates strategies to empower students to take responsibility for their own learning in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

**Pat** demonstrates strategies to ensure that the science inquiry activities she does with her students lead to higher-level thinking and deeper understanding in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

**Nancy** demonstrates strategies to ensure that the science inquiry activities she does with her students lead to higher-level thinking and deeper understanding in this video on demand produced by Annenberg. While not all the content shown relates to this content statement, the strategies shown can be adapted to all science content.

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

BACK TO INDEX

# Ohio Revised Science Standards and Model Curriculum High School

## Physical Science

### SYLLABUS AND MODEL CURRICULUM

#### COURSE DESCRIPTION

Physical science is a high school level course, which satisfies the **Ohio Core** science graduation requirements of **Ohio Revised Code Section 3313.603**. This section of Ohio law requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

Physical science introduces students to key concepts and theories that provide a foundation for further study in other sciences and advanced science disciplines. Physical science comprises the systematic study of the physical world as it relates to fundamental concepts about matter, energy and motion. A unified understanding of phenomena in physical, living, Earth and space systems is the culmination of all previously learned concepts related to chemistry, physics, and Earth and space science, along with historical perspective and mathematical reasoning.

#### SCIENCE INQUIRY AND APPLICATION

During the years of grades 9 through 12, all students must use the following scientific processes with appropriate **laboratory safety techniques** to construct their knowledge and understanding in all science content areas:

- Identify questions and concepts that guide scientific investigations;
- Design and conduct **scientific investigations**;
- Use technology and mathematics to improve investigations and communications;
- Formulate and revise explanations and models using logic and evidence (critical thinking);
- Recognize and analyze explanations and models; and
- Communicate and support a scientific argument.

#### COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

#### STUDY OF MATTER

- Classification of matter
  - Heterogeneous vs. homogeneous
  - Properties of matter
  - States of matter and its changes
- Atoms
  - Models of the atom (components)
  - Ions (cations and anions)
  - Isotopes
- Periodic trends of the elements
  - Periodic law
  - Representative groups
- Bonding and compounds
  - Bonding (ionic and covalent)
  - Nomenclature
- Reactions of matter
  - Chemical reactions
  - Nuclear reactions

#### ENERGY AND WAVES

- Conservation of energy
  - Quantifying kinetic energy
  - Quantifying gravitational potential energy
  - Energy is relative
- Transfer and transformation of energy (including work)
- Waves
  - Refraction, reflection, diffraction, absorption, superposition
  - Radiant energy and the electromagnetic spectrum
  - Doppler shift
- Thermal energy
- Electricity
  - Movement of electrons
  - Current
  - Electric potential (voltage)
  - Resistors and transfer of energy

BACK TO INDEX

## FORCES AND MOTION

- Motion
  - Introduction to one-dimensional vectors
  - Displacement, velocity (constant, average and instantaneous) and acceleration
  - Interpreting position vs. time and velocity vs. time graphs
- Forces
  - Force diagrams
  - Types of forces (gravity, friction, normal, tension)
  - Field model for forces at a distance
- Dynamics (how forces affect motion)
  - Objects at rest
  - Objects moving with constant velocity
  - Accelerating objects

## THE UNIVERSE

- History of the universe
- Galaxy formation
- Stars
  - Formation; stages of evolution
  - Fusion in stars

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

## CONTENT ELABORATION: STUDY OF MATTER

### Classification of Matter

Matter was introduced in the elementary grades and the learning progression continued through middle school to include differences in the physical properties of solids, liquids and gases, elements, compounds, mixtures, molecules, kinetic and potential energy and the particulate nature of matter. Content in the chemistry syllabus (e.g., electron configuration, molecular shapes, bond angles) will be developed from concepts in this course.

Matter can be classified in broad categories such as homogeneous and heterogeneous or classified according to its composition or by its chemical (reactivity) and physical properties (e.g., color, solubility, odor, hardness, density, conductivity, melting point and boiling point, viscosity and malleability).

Solutions are homogenous mixtures of a solute dissolved in a solvent. The amount of a solid solute that can dissolve in a solvent generally increases as the temperature increases since the particles have more kinetic energy to overcome the attractive forces between them. Water is often used as a solvent since so many substances will dissolve in water. Physical properties can be used to separate the substances in mixtures, including solutions.

Phase changes can be represented by graphing the temperature of a sample vs. the time it has been heated. Investigations must include collecting data during heating, cooling and solid-liquid- solid phase changes. At times, the temperature will change steadily, indicating a change in the motion of the particles and the kinetic energy of the substance. However, during a phase change, the temperature of a substance does not change, indicating there is no change in kinetic energy. Since the substance continues to gain or lose energy during phase changes, these changes in energy are potential and indicate a change in the position of the particles. When heating a substance, a phase change will occur when the kinetic energy of the particles is great enough to overcome the attractive forces between the particles; the substance then melts or boils. Conversely, when cooling a substance, a phase change will occur when the kinetic energy of the particles is no longer great enough to overcome the attractive forces between the particles; the substance then condenses or freezes. Phase changes are examples of changes that can occur when energy is absorbed from the surroundings (endothermic) or released into the surroundings (exothermic).

When thermal energy is added to a solid, liquid or gas, most substances increase in volume because the increased kinetic energy of the particles causes an increased distance between the particles. This results in a change in density of the material. Generally, solids have greater density than liquids, which have greater density than gases due to the spacing between the particles. The density of a substance can be calculated from the slope of a mass vs. volume graph. Differences in densities can be determined by interpreting mass vs. volume graphs of the substances.

### Atoms

Content introduced in middle school, where the atom was introduced as a small, indestructible sphere, is further developed in the physical science syllabus. Over time, technology was introduced that allowed the atom to be studied in more detail. The atom is composed of protons, neutrons and electrons that have measurable properties, including mass and, in the case of protons and electrons, a characteristic charge. When bombarding thin gold foil with atomic-sized, positively charged, high-speed particles, a few of the particles were deflected slightly from their straight-line path. Even fewer bounced back toward the source. This evidence indicates that most of an atom is empty space with a very small positively charged nucleus. This experiment and other evidence indicate the nucleus is composed of protons and neutrons, and electrons that move about in the empty space that surrounds the nucleus. Additional experimental evidence that led to the development of other historic atomic models will be addressed in the chemistry syllabus.

All atoms of a particular element have the same atomic number; an element may have different isotopes with different mass numbers. Atoms may gain or lose valence electrons to become anions or cations. Atomic number, mass number, charge and identity of the element can be determined from the numbers of protons, neutrons and electrons. Each element has a unique atomic spectrum that can be observed and used to identify an element. Atomic mass and explanations about how atomic spectra are produced are addressed in the chemistry syllabus.

### Periodic Trends of the Elements

Content from the middle school level, specifically the properties of metals and nonmetals and their positions on the periodic table, is further expanded in this course. When elements are listed in order of increasing atomic number, the same sequence of properties appears over and over again; this is the periodic law. The periodic table is arranged so that elements with similar chemical and physical properties are in the same group or family. Metalloids are elements that have some properties of metals and some properties of nonmetals. Metals, nonmetals, metalloids, periods and groups or families including the alkali metals, alkaline earth metals, halogens and noble gases can be identified by their position on the periodic table. Elements in Groups 1, 2 and 17 have characteristic ionic charges that will be used in this course to predict the formulas of compounds. Other trends in the periodic table (e.g., atomic radius, electronegativity, ionization energies) are found in the chemistry syllabus.

### Bonding and Compounds

Middle school content included compounds are composed of atoms of two or more elements joined together chemically. In this course, the chemical joining of atoms is studied in more detail. Atoms may be bonded together by losing, gaining or sharing valence electrons to form molecules or three- dimensional lattices. An ionic bond involves the attraction of two oppositely charged ions, typically a metal cation and a

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

nonmetal anion formed by transferring electrons between the atoms. An ion attracts oppositely charged ions from every direction, resulting in the formation of a three-dimensional lattice. Covalent bonds result from the sharing of electrons between two atoms, usually nonmetals. Covalent bonding can result in the formation of structures ranging from small individual molecules to three-dimensional lattices (e.g., diamond). The bonds in most compounds fall on a continuum between the two extreme models of bonding: ionic and covalent.

Using the periodic table to determine ionic charge, formulas of ionic compounds containing elements from groups 1, 2, 17, hydrogen and oxygen can be predicted. Given a chemical formula, a compound can be named using conventional systems that include Greek prefixes where appropriate. Prefixes will be limited to represent values from one to 10. Given the name of an ionic or covalent substance, formulas can be written. Naming organic molecules is beyond this grade level and is reserved for an advanced chemistry course. Prediction of bond types from electronegativity values, polar covalent bonds, writing formulas and naming compounds that contain polyatomic ions or transition metals will be addressed in the chemistry syllabus.

### Reactions of Matter

In middle school, the law of conservation of matter was expanded to chemical reactions, noting that the number and type of atoms and the total mass are the same before and after the reaction. In this course, conservation of matter is expressed by writing balanced chemical equations. At this level, reactants and products can be identified from an equation and simple equations can be written and balanced given either the formulas of the reactants and products or a word description of the reaction. Stoichiometric relationships beyond the coefficients in a balanced equation and classification of types of chemical reactions are addressed in the chemistry syllabus.

During chemical reactions, thermal energy is either transferred from the system to the surroundings (exothermic) or transferred from the surroundings to the system (endothermic). Since the environment surrounding the system can be large, temperature changes in the surroundings may not be detectable.

While chemical changes involve changes in the electrons, nuclear reactions involve changes to the nucleus and involve much larger energies than chemical reactions. The strong nuclear force is the attractive force that binds protons and neutrons together in the nucleus. While the nuclear force is extremely weak at most distances, over the very short distances present in the nucleus the force is greater than the repulsive electrical forces among protons. When the attractive nuclear forces and repulsive electrical forces in the nucleus are not balanced, the nucleus is unstable. Through radioactive decay, the unstable nucleus emits radiation in the form of very fast-moving particles and energy to produce a new nucleus, thus changing the identity of the element. Nuclei that undergo this process are said to be radioactive. Radioactive isotopes have several medical applications. The radiation they release can be used to kill undesired cells (e.g., cancer cells). Radioisotopes can be introduced into the body to show the flow of materials in biological processes.

For any radioisotope, the half-life is unique and constant. Graphs can be constructed that show the amount of a radioisotope that remains as a function of time and can be interpreted to determine the value of the half-life. Half-life values are used in radioactive dating.

Other examples of nuclear processes include nuclear fission and nuclear fusion. Nuclear fission involves splitting a large nucleus into smaller nuclei, releasing large quantities of energy. Nuclear fusion is the joining of smaller nuclei into a larger nucleus accompanied by the release of large quantities of energy. Nuclear fusion is the process responsible for formation of all the elements in the universe beyond helium and the energy of the sun and the stars.

Further details about nuclear processes including common types of nuclear radiation, predicting the products of nuclear decay, mass-energy equivalence and nuclear power applications are addressed in the chemistry and physics syllabi.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE

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

- Visually compare the inside structure of various balls (tennis ball, golf ball, baseball, basketball/kickball and soccer ball). Determine what makes the ball bounce the highest (and/or travel farthest), compare, analyze the data, draw conclusions and present findings in multiple formats.
- Explore the benefits of radiation and how it can be used as a tool to sustain life (sterilization and food irradiation processes, nuclear medicine). Include details about how the radiation works to accomplish the benefit and the extent (limit or range) that the benefit will continue as opposed to becoming a harm to life (plants, animals or human beings) on Earth. Draw conclusions and present an argument based on supporting data as to when radiation poses a threat as opposed to being beneficial. Present findings in multiple formats.

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **The Rutherford experiment** is a simulation that shows high-speed particles bombarding a thin foil. While the simulation is not to scale, it does provide a dynamic visual to help students understand what is happening at the atomic level that explains the experimental evidence.

## COMMON MISCONCEPTIONS

- Students may think that models are physical copies of the real thing, failing to recognize models as conceptual representations. (AAAS, 1993)
- Students know models can be changed, but at the high school level, they may be limited by thinking that a change in a model means adding new information or that changing a model means replacing a part that was wrong. (AAAS, 1993)
- Students often do not believe models can duplicate reality. (AAAS, 1993)
- Students often think that breaking bonds releases energy. (Ross, 1993)
- When multiple models are presented, they tend to think there is one "right one". (AAAS, 1993)

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

"**Teaching High School Science**" is a series of videos-on-demand produced by Annenberg that show classroom strategies for implementing inquiry into the high school classroom. While not all of the content is aligned to physical science, the strategies can be applied to any content.

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

## CONTENT ELABORATION: ENERGY AND WAVES

### Energy and Waves

Building upon knowledge gained in elementary and middle school, major concepts about energy and waves are further developed. Conceptual knowledge will move from qualitative understandings of energy and waves to ones that are more quantitative using mathematical formulas, manipulations and graphical representations.

- **Conservation of Energy**
  Energy content learned in middle school, specifically conservation of energy and the basic differences between kinetic and potential energy, is elaborated on and quantified in this course. Energy has no direction and has units of Joules (J). Kinetic energy, $E_k$, can be mathematically represented by $E_k = \frac{1}{2}mv^2$. Gravitational potential energy, $E_g$, can be mathematically represented by $E_g = mgh$,. The amount of energy of an object is measured relative to a reference that is considered to be at a point of zero energy. The reference may be changed to help understand different situations. Only the change in the amount of energy can be measured absolutely. The conservation of energy and equations for kinetic and gravitational potential energy can be used to calculate values associated with energy (i.e., height, mass, speed) for situations involving energy transfer and transformation. Opportunities to quantify energy from data collected in experimental situations (e.g., a swinging pendulum, a car traveling down an incline) must be provided.
- **Transfer and Transformation of Energy**
  In middle school, concepts of energy transfer and transformation were addressed, including conservation of energy, conduction, convection and radiation, the transformation of electrical energy, and the dissipation of energy into thermal energy. Work also was introduced as a method of energy transfer into or out of the system when an outside force moves an object over a distance. In this course, these concepts are further developed. As long as the force, $F$, and displacement, $\Delta x$, are in the same or opposite directions, work, $W$, can be calculated from the equation $W = F\Delta x$. Energy transformations for a phenomenon can be represented through a series of pie graphs or bar graphs. Equations for work, kinetic energy and potential energy can be combined with the law of conservation of energy to solve problems. When energy is transferred from one system to another, some of the energy is transformed to thermal energy. Since thermal energy involves the random movement of many trillions of subatomic particles, it is less able to be organized to bring about further change. Therefore, even though the total amount of energy remains constant, less energy is available for doing useful work.
- **Waves**
  As addressed in middle school, waves transmit energy from one place to another, can transfer energy between objects and can be described by their speed, wavelength, frequency and amplitude. The relationship between speed, wavelength and frequency also was addressed in middle school Earth and Space Science as the motion of seismic waves through different materials is studied.

  In elementary and middle school, reflection and refraction of light were introduced, as was absorption of radiant energy by transformation into thermal energy. In this course, these processes are addressed from the perspective of waves and expanded to include other types of energy that travel in waves. When a wave encounters a new material, the new material may absorb the energy of the wave by transforming it to another form of energy, usually thermal energy. Waves can be reflected off solid barriers or refracted when a wave travels form one medium into another medium. Waves may undergo diffraction around small obstacles or openings. When two waves traveling through the same medium meet, they pass through each other then continue traveling through the medium as before. When the waves meet, they undergo superposition, demonstrating constructive and destructive interference. Sound travels in waves and undergoes reflection, refraction, interference and diffraction. In the physics syllabus, many of these wave phenomena will be studied further and quantified.

  Radiant energy travels in waves and does not require a medium. Sources of light energy (e.g., the sun, a light bulb) radiate energy continually in all directions. Radiant energy has a wide range of frequencies, wavelengths and energies arranged into the electromagnetic spectrum. The electromagnetic spectrum is divided into bands: radio (lowest energy), microwaves, infrared, visible light, X-rays and gamma rays (highest energy) that have different applications in everyday life. Radiant energy of the entire electromagnetic spectrum travels at the same speed in a vacuum. Specific frequency, energy or wavelength ranges of the electromagnetic spectrum are not required. However, the relative positions of the different bands, including the colors of visible light, are important (e.g., ultraviolet has more energy than microwaves). Radiant energy exhibits wave behaviors including reflection, refraction, absorption, superposition and diffraction, depending in part on the nature of the medium. For opaque objects (e.g., paper, a chair, an apple), little if any radiant energy is transmitted into the new material. However the radiant energy can be absorbed, usually increasing the thermal energy of the object and/or the radiant energy can be reflected. For rough objects, the reflection in all directions forms a diffuse reflection and for smooth shiny objects, reflections can result in clear images. Transparent materials transmit most of the energy through the material but smaller amounts of energy may be absorbed or reflected.

  Changes in the observed frequency and wavelength of a wave can occur if the wave source and the observer are moving relative to each other. When the source and the observer are moving toward each other, the wavelength is shorter and the

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

observed frequency is higher; when the source and the observer are moving away from each other, the wavelength is longer and the observed frequency is lower. This phenomenon is called the Doppler shift and can be explained using diagrams. This phenomenon is important to current understanding of how the universe was formed and will be applied in later sections of this course. Calculations to measure the apparent change in frequency or wavelength are not appropriate for this course.

- **Thermal Energy**
  In middle school, thermal energy is introduced as the energy of movement of the particles that make up matter. Processes of heat transfer, including conduction, convection and radiation, are studied. In other sections of this course, the role of thermal energy during heating, cooling and phase changes is explored conceptually and graphically. In this course, rates of thermal energy transfer and thermal equilibrium are introduced.

  Thermal conductivity depends on the rate at which thermal energy is transferred from one end of a material to another. Thermal conductors have a high rate of thermal energy transfer and thermal insulators have a slow rate of thermal energy transfer. The rate at which thermal radiation is absorbed or emitted by a system depends on its temperature, color, texture and exposed surface area. All other things being equal, in a given amount of time, black rough surfaces absorb more thermal energy than smooth white surfaces. An object or system is continually absorbing and emitting thermal radiation. If the object or system absorbs more thermal energy than it emits and there is no change in phase, the temperature increases. If the object or system emits more thermal energy than is absorbed and there is no change in phase, the temperature decreases. For an object or system in thermal equilibrium, the amount of thermal energy absorbed is equal to the amount of thermal energy emitted; therefore, the temperature remains constant. In chemistry, changes in thermal energy are quantified for substances that change their temperature.
- **Electricity**
  In earlier grades, these concepts were introduced: electrical conductors and insulators; and a complete loop is needed for an electrical circuit that may be parallel or in a series. In this course, circuits are explained by the flow of electrons, and current, voltage and resistance are introduced conceptually to explain what was observed in middle school. The differences between electrical conductors and insulators can be explained by how freely the electrons flow throughout the material due to how firmly electrons are held by the nucleus.

  By convention, electric current is the rate at which positive charge flows in a circuit. In reality, it is the negatively charged electrons that are actually moving. Current is measured in amperes (A), which is equal to one coulomb of charge per second (C/s). In an electric circuit, the power source supplies the electrons already in the circuit with electric potential energy by doing work to separate opposite charges. For a battery, the energy is provided by a chemical reaction that separates charges on the positive and negative sides of the battery. This separation of charge is what causes the electrons to flow in the circuit. These electrons then transfer energy to other objects and transform electrical energy into other forms (e.g., light, sound, heat) in the resistors. Current continues to flow, even after the electrons transfer their energy. Resistors oppose the rate of charge flow in the circuit. The potential difference or voltage across an energy source is a measure of potential energy in Joules supplied to each coulomb of charge. The volt (V) is the unit of potential difference and is equal to one Joule of energy per coulomb of charge (J/C). Potential difference across the circuit is a property of the energy source and does not depend upon the devices in the circuit. These concepts can be used to explain why current will increase as the potential difference increases and as the resistance decreases. Experiments, investigations and testing (3-D or virtual) must be used to construct a variety of circuits, and measure and compare the potential difference (voltage) and current. Electricity concepts are dealt with conceptually in this course. Calculations with circuits will be addressed in the physics syllabus.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE

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

- Design, build and test a ramp system onto which a ball can be placed so that it rolls down a ramp and continues a specific distance on the table. Describe what properties of the system were important (and those not important) in the design. Provide different target distances for the launched ball to travel on the designed course and hit a given target within three trials.
- Investigate the relationship between speed, frequency and wavelength for a transverse wave traveling through a Slinky®. Make claims about what happens to the speed and the wavelength of the wave as the frequency is increased and give evidence to support any claims. For example, use information from the investigation to explore the implications of cell phone usage. Include beneficial and harmful aspects of the use of this technology for a modern convenience. Present findings and draw a conclusion using data and research in multiple formats.

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- "**Waves, Light, and Sound**" from The Physics Zone links to many animations of waves that can be used with absent students or students who need more reinforcement. Simulations also may be good to slow down some of the phenomena that students observe in class so they can make observations that are more detailed. Some of the simulations can only be accessed by members, but many of the simulations have unrestricted access.
- **Modeling workshops** are available nationally that help teachers develop a framework for using guided inquiry in their instruction.

### Career Connection

As students explore the flow of electric current, resistors, and transfer of energy, they will identify issues found after a severe storm disrupts electricity across an area. Students will look into how current flows and what occurs during a storm that interrupts or interferes with the transfer of electricity. Students will identify potential problems caused by the storm. Then, they will generate a plan to restore electricity by determining which careers are needed and their respective roles in the process. Students will research aspects of careers, such as: job outlook for these careers in Ohio; current demand; education and training requirements (high school and beyond); and wages, working conditions, and typical tasks.

## COMMON MISCONCEPTIONS

**Students often think that:**

- Potential energy is a thing that objects hold (like cereal stored in a closet).
- The only type of potential energy is gravitational.
- Doubling the velocity of a moving object will double its kinetic energy.
- Stored energy is something that causes energy later; it is not energy until it has been released.
- Objects do not have any energy if they are not moving.
- Energy is a thing that can be created and destroyed.
- Energy is literally lost in many energy transformations.
- Gravitational potential energy depends only upon the height of an object.
- Energy can be changed completely from one form to another with no loss of useful energy.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

"**Teaching High School Science**" is a series of videos-on-demand produced by Annenberg that show classroom strategies for implementing inquiry into the high school classroom. While not all of the content is aligned to physical science, the strategies can be applied to any content.

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

## CONTENT ELABORATION: FORCES AND MOTION

### Forces and Motion

Building upon content in elementary and middle school, major concepts of motion and forces are further developed. In middle school, speed has been dealt with conceptually, mathematically and graphically. The concept that forces have both magnitude and direction can be represented with a force diagram, that forces can be added to find a net force and that forces may affect motion has been addressed in middle school. At the high school level, mathematics (including graphing) is used when describing these phenomena, moving from qualitative understanding to one that is more quantitative. For the physical science course, all motion is limited to objects moving in a straight line either horizontally, vertically, up an incline or down an incline, that can be characterized by segments of uniform motion (e.g., at rest, constant velocity, constant acceleration). Motions of two objects may be compared or addressed simultaneously (e.g., when or where would they meet).

- **Motion**

  The motion of an object depends on the observer's frame of reference and is described in terms of distance, position, displacement, speed, velocity, acceleration and time. Position, displacement, velocity and acceleration are all vector properties (magnitude and direction). All motion is relative to whatever frame of reference is chosen, for there is no motionless frame from which to judge all motion. The relative nature of motion will be addressed conceptually, not mathematically. Non- inertial reference frames are excluded. **Motion diagrams** can be drawn and interpreted to represent the position and velocity of an object. Showing the acceleration on motion diagrams will be reserved for physics.

  The displacement or change in position of an object is a vector quantity that can be calculated by subtracting the initial position from the final position ($\Delta x = x_f - x_i$). Displacement can be positive or negative depending upon the direction of motion. Displacement is not always equal to the distance travelled. Examples should be given where the distance is not the same as the displacement.

  Velocity is a vector property that represents the rate at which position changes. Average velocity can be calculated by dividing displacement (change in position) by the elapsed time ($v_{avg} = (x_f - x_i)/(t_f - t_i)$). Velocity may be positive or negative depending upon the direction of motion and is not always equal to the speed. Provide examples of when the average speed is not the same as the average velocity. Objects that move with constant velocity have the same displacement for each successive time interval. While speeding up or slowing down and/or changing direction, the velocity of an object changes continuously, from instant to instant. The speed of an object at any instant (clock reading) is called instantaneous speed. An object may not travel at this instantaneous speed for any period of time or cover any distance with that particular speed, especially if the speed is continually changing.

  Acceleration is a vector property that represents the rate at which velocity changes. Average acceleration can be calculated by dividing the change in velocity divided by elapsed time ($a_{avg} = (v_f - v_i)/(t_f - t_i)$). At this grade level, it should be noted that acceleration can be positive or negative, but specifics about what kind of motions produce positive or negative accelerations will be addressed in the physics syllabus. The word "deceleration" should not be used because students tend to associate a negative sign of acceleration only with slowing down. Objects that have no acceleration can either be standing still or be moving with constant velocity (speed and direction). Constant acceleration occurs when the change in an object's instantaneous velocity is the same for equal successive time intervals.

  Motion can be represented by position vs. time and velocity vs. time graphs. Specifics about the speed, direction and change in motion can be determined by interpreting such graphs. For physical science, graphs will be limited to positive x-values and show only uniform motion involving segments of constant velocity or constant acceleration. Motion must be investigated by collecting and analyzing data in the laboratory. Technology can enhance motion exploration and investigation through video analysis, the use of motion detectors and graphing data for analysis.

  Objects that move with constant velocity and have no acceleration form a straight line (not necessarily horizontal) on a position vs. time graph. Objects that are at rest will form a straight horizontal line on a position vs. time graph. Objects that are accelerating will show a curved line on a position vs. time graph. Velocity can be calculated by determining the slope of a position vs. time graph. Positive slopes on position vs. time graphs indicate motion in a positive direction. Negative slopes on position vs. time graphs indicate motion in a negative direction. While it is important that students can construct graphs by hand, computer graphing programs or graphing calculators also can be used so more time can be spent on graph interpretation and analysis.

  Constant acceleration is represented by a straight line (not necessarily horizontal) on a velocity vs. time graph. Objects that have no acceleration (at rest or moving at constant velocity) will have a straight horizontal line for a velocity vs. time graph. Average acceleration can be determined from the slope of a velocity vs. time graph. The details about motion graphs should not be taught as rules to memorize, but rather as generalizations that can be developed from interpreting the graphs.

- **Forces**

  Force is a vector quantity, having both magnitude and direction. The (SI) unit of force is a Newton. One Newton of net force will cause a 1 kg object to experience an acceleration of 1 $m/s^2$. A Newton also can be represented as $kg \cdot m/s^2$. The opportunity to measure force in the lab must be provided (e.g., with a spring scale or a force probe). Normal forces and tension forces are introduced conceptually at this level. These forces and other forces introduced in prior grades (friction, drag, contact, gravitational, electric and magnetic) and can be used as examples

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

of forces that affect motion. Gravitational force (weight) can be calculated from mass, but all other forces will only be quantified from force diagrams that were introduced in middle school. In physical science, only forces in one dimension (positive and negative) will be addressed. The net force can be determined by one-dimensional vector addition. More quantitative study of friction forces, universal gravitational forces, elastic forces and electrical forces will be addressed in the physics syllabus.

Friction is a force that opposes sliding between two surfaces. For surfaces that are sliding relative to each other, the force on an object always points in a direction opposite to the relative motion of the object. In physical science, friction will only be calculated from force diagrams. Equations for static and kinetic friction are found in the physics syllabus.

A normal force exists between two solid objects when their surfaces are pressed together due to other forces acting on one or both objects (e.g., a solid sitting on or sliding across a table, a magnet attached to a refrigerator). A normal force is always a push directed at right angles from the surfaces of the interacting objects. A tension force occurs when a non-slack rope, wire, cord or similar device pulls on another object. The tension force always points in the direction of the pull.

In middle school, the concept of a field as a region of space that surrounds objects with the appropriate property (mass for gravitational fields, charge for electric fields, a magnetic object for magnetic fields) was introduced to explain gravitational, magnetic and electrical forces that occur over a distance. The field concept is further developed in physical science. The stronger the field, the greater the force exerted on objects placed in the field. The field of an object is always there, even if the object is not interacting with anything else. The gravitational force (weight) of an object is proportional to its mass. Weight, Fg, can be calculated from the equation $F_g = m\,g$, where $g$ is the gravitational field strength of an object which is equal to $9.8\ N/kg$ ($m/s^2$) on the surface of Earth.

- **Dynamics**

  An object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced net force acts on it. The rate at which an object changes its speed or direction (acceleration) is proportional to the vector sum of the applied forces (net force, $F_{net}$) and inversely proportional to the mass ($a = F_{net}/m$). When the vector sum of the forces (net force) acting on an object is zero, the object does not accelerate. For an object that is moving, this means the object will remain moving without changing its speed or direction. For an object that is not moving, the object will continue to remain stationary. These laws will be applied to systems consisting of a single object upon which multiple forces act. Vector addition will be limited to one dimension (positive and negative). While both horizontal and vertical forces can be acting on an object simultaneously, one of the dimensions must have a net force of zero.

  A force is an interaction between two objects. Both objects in the interaction experience an equal amount of force, but in opposite directions. Interacting force pairs are often confused with balanced forces. Interacting force pairs can never cancel each other out because they always act on different objects. Naming the force (e.g., gravity, friction) does not identify the two objects involved in the interacting force pair. Objects involved in an interacting force pair can be easily identified by using the format "A acts on B so B acts on A." For example, the truck hits the sign therefore the sign hits the truck with an equal force in the opposite direction. Earth pulls the book down so the book pulls Earth up with an equal force. The focus of the content is to develop a conceptual understanding of the laws of motion to explain and predict changes in motion, not to name or recite a memorized definition. In the physics syllabus, all laws will be applied to systems of many objects.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE

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

- Research the ranges of human reaction time and braking accelerations. Design a traffic light pattern (e.g., how long the light should stay yellow) for a particular intersection, given the speed limits. Present the design and rationale to the class. Compare the results for different speed limits. Explain any patterns and trends observed.
- Investigate the relationship between position and time for a cart that rolls down a ramp from rest. Graph the results. Make a claim about how position and time are related and use evidence to support the claim. Present the findings to the class. Based on the presentations of other investigations, propose sources of error and provide suggestions for how the experiments can be improved.

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- "**Forces in 1 Dimension**" is an interactive simulation that allows students to explore the forces at work when trying to push a filing cabinet. An applied force is created and the resulting friction force and total force acting on the cabinet are then shown. Forces vs. time, position vs. time, velocity vs. time, and acceleration vs. time graphs can be shown as can force diagrams representing all the forces (including gravitational and normal forces).
- "**Motion Diagrams**" is a tutorial from Western Kentucky University that shows how to draw motion diagrams for a variety of motions. It includes an animated physlet. Motion diagrams in physical science will only show position and velocity and will not show acceleration.
- The Physics Classroom supports this tutorial on **one-dimensional motion** that gives a thorough explanation of acceleration, including an animation to use with students who may still be having difficulties with acceleration.
- **Modeling workshops** are available nationally that help teachers develop a framework for incorporating guided inquiry in their instruction.

## COMMON MISCONCEPTIONS

It is often thought that the exertion of a force requires a conscious decision by a thinking entity. Using the common terms "action" and "reaction" when designating forces from the perspective of Newton's third law can reinforce this misconception. Using the descriptor "interacting force pair" does not perpetuate this misconception and honors the fact that the two forces are mutually important.

Students often think that:

- **If the speed** is constant, then there is no acceleration.
- High velocities coincide with large accelerations and low velocities coincide with small accelerations.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

"**Teaching High School Science**" is a series of videos-on-demand produced by Annenberg that show classroom strategies for implementing inquiry into the high school classroom. While not all of the content is aligned to physical science, the strategies can be applied to any content.

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

## CONTENT ELABORATION: THE UNIVERSE

### The Universe

In early elementary school, observations of the sky and space are the foundation for developing a deeper knowledge of the solar system. In late elementary school, the parts of the solar system are introduced, including characteristics of the sun and planets, orbits and celestial bodies. At the middle school level, energy, waves, gravity and density are emphasized in the physical sciences, and characteristics and patterns within the solar system are found.

In the physical science course, the universe and galaxies are introduced, building upon the previous knowledge about space and the solar system in the earlier grades.

- **History of the Universe**
  The Big Bang Model is a broadly accepted theory for the origin and evolution of our universe. It postulates that 12 to 14 billion years ago, the portion of the universe seen today was only a few millimeters across (**NASA**).

  According to the "**big bang**" theory, the contents of the known universe expanded explosively into existence from a hot, dense state 13.7 billion years ago (NAEP 2009). After the big bang, the universe expanded quickly (and continues to expand) and then cooled down enough for atoms to form. Gravity pulled the atoms together into gas clouds that eventually became stars, which comprise young galaxies. Foundations for the big bang model can be included to introduce the supporting evidence for the expansion of the known universe (e.g., Hubble's law and red shift or cosmic microwave background radiation). A discussion of Hubble's law and red shift is found in the *Galaxy formation* section, below.

  Technology provides the basis for many new discoveries related to space and the universe. Visual, radio and x-ray telescopes collect information from across the entire electromagnetic spectrum; computers are used to manage data and complicated computations; space probes send back data and materials from remote parts of the solar system; and accelerators provide subatomic particle energies that simulate conditions in the stars and in the early history of the universe before stars formed.
- **Galaxy formation**
  A galaxy is a group of billions of individual stars, star systems, star clusters, dust and gas bound together by gravity. There are **billions of galaxies in the universe**, and they are classified by size and shape. The Milky Way is a spiral galaxy. It has more than 100 billion stars and a diameter of more than 100,000 light years. At the center of the Milky Way is a collection of stars bulging outward from the disk, from which extend spiral arms of gas, dust and most of the young stars. The solar system is part of the Milky Way galaxy.

  Hubble's law states that galaxies that are farther away have a greater red shift, so the speed at which a galaxy is moving away is proportional to its distance from the Earth. Red shift is a phenomenon due to Doppler shifting, so the shift of light from a galaxy to the red end of the spectrum indicates that the galaxy and the observer are moving farther away from one another. Doppler shifting also is found in the *Energy and Waves* section of this course.
- **Stars**
  Early in the formation of the universe, stars coalesced out of clouds of hydrogen and helium and clumped together by gravitational attraction into galaxies. When heated to a sufficiently high temperature by gravitational attraction, stars begin nuclear reactions, which convert matter to energy and fuse the lighter elements into heavier ones. These and other fusion processes in stars have led to the formation of all the other elements. (NAEP 2009). All of the elements, except for hydrogen and helium, originated from the nuclear fusion reactions of stars (College Board Standards for College Success, 2009).

  Stars are classified by their color, size, luminosity and mass. A **Hertzprung-Russell diagram** must be used to estimate the sizes of stars and predict how stars will evolve. Most stars fall on the main sequence of the H-R diagram, a diagonal band running from the bright hot stars on the upper left to the dim cool stars on the lower right.

  A star's mass determines the star's place on the main sequence and how long it will stay there. Patterns of stellar evolution are based on the mass of the star. Stars begin to collapse as the core energy dissipates. Nuclear reactions outside the core cause expansion of the star, eventually leading to the **collapse of the star**.

  **Note: Names of stars and naming the evolutionary stage of a star from memory will not be assessed. The emphasis is on the interpretation of data (using diagrams and charts) and the criteria and processes needed to make those determinations.**

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Investigate features of a solid planetary body using the **WorldWide Telescope**. Identify features that are oldest verses those that are youngest and draw conclusions about the reasons for the differences using current theory to support the conclusions.
- Investigate the relative ages of star clusters by plotting data and analyzing the

BACK TO INDEX

BACK TO PHYSICAL SCIENCE OUTLINE

results of the graph created (creating an H-R diagram). Draw conclusions based on the results of the graph and discuss possible implications of the information learned (see **Student Instructions** and **Star Gauge**).

- Evaluate data analyzing the penetration ability of Gamma radiation, X-rays, UV, visible light, infrared and radio wavelengths in Earth's atmosphere. Based on the analysis and pertinent wavelength-study considerations (e.g., certain wavelengths of light are blocked from reaching Earth's surface by the atmosphere; how efficiently telescopes work at different wavelengths; telescopes in space are much more expensive to construct than Earth-based telescopes) recommend to a federal funding agency which telescope project should receive funds for construction. The two projects to consider are:
  - **Project 1** – A UV wavelength telescope, placed high atop Mauna Kea in Hawaii at 14,000 ft. above sea level, which will be used to look at distant galaxies.
  - **Project 2** – A visible wavelength telescope, placed on a satellite in orbit around Earth, which will be used to observe a pair of binary stars located in the constellation Ursa Major (Big Dipper). (Prather, Slater, Adams, & Brissenden, 2008)
- Use real-time data from the **NASA Hubble Mission** to research and document the history of the mission, marking the time, discoveries and impact to humans. There are links at the NASA site to connect students to astronauts and scientists to allow for primary and secondary resources in the research. Present a final product (can be an e-portfolio, presentation or formal poster session) to an authentic audience.

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- A **collection of videos** is provided by NASA about the **James Webb Telescope** – the largest space-based observatory ever built to date. From galaxy evolution to planetary formation, the Webb telescope will equip scientists to see far beyond previous endeavors.
- Investigate the **star life cycle** with interactive media or gain an overview of astronomical spectroscopy in studies of stellar spectra.
- It is important to keep the evidence **supporting the big bang model** at the grade 9-10 level. Students should understand where the evidence for the theory is found and the importance of data that support the expansion of the universe. This article provides a higher level of detail than is required for this course, but sections of the article are helpful and appropriate in understanding the foundational support.
- **NASA** provides science modules to support teaching about red shift and Doppler effects from a cosmology viewpoint. There also are NASA documents that can assist in teaching about **stellar evolution**.
- Use an **interactive HR Diagram** to explore different patterns that can exist on the chart and the evolution of specific types of stars.
- **Astronomy: Eliciting Student Ideas** is a workshop produced by Annenberg that uses constructivism by examining student beliefs on what causes the seasons and their explanations for the phases of the moon that are explored in the video-on-demand "**A Private Universe**."
- **The Quantum Mechanical Universe** is a video produced by Annenberg about a current look at where we have been and a peek into the future.
- **Dying stars and Birth of Elements** is a computer-based exercise where high school students analyze realistically simulated X-ray spectra of a supernova remnant and determine the abundances of various elements in them. In the end, they will find that the elements necessary for life on Earth – the iron in their blood, the calcium in their bones – are created in these distant explosions.
- "**A Star is Born... but How**?" and "**Stars**" are two tutorials on the Windows to the Universe from the National Earth Science Teachers Association that give details about star formation.
- **Exploring Mars** is a video produced by Annenberg that shows students in a grade 11 integrated science class who explore how the Mars landscape may have formed.

## COMMON MISCONCEPTIONS

- **NASA** provides general student misconceptions pertaining to the universe and the big bang theory.
- Students' understanding of the magnitude of the universe needs to developed where they can make sense of how large is a billion or a million. Keely, Eberle & Tugel (2005) suggests teaching the notion of scale with familiar objects that students can see, like the moon and sun. Gradually introduce the nearby planets and then planets further away (p.182)

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

"**Teaching High School Science**" is a series of videos-on-demand produced by Annenberg that show classroom strategies for implementing inquiry into the high school classroom. While not all of the content is aligned to physical science, the strategies can be applied to any content.

BACK TO INDEX

# Biology

## SYLLABUS AND MODEL CURRICULUM

### COURSE DESCRIPTION

Biology is a high school level course, which satisfies the **Ohio Core** science graduation requirements of **Ohio Revised Code Section 3313.603**. This section of Ohio law requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

This course investigates the composition, diversity, complexity and interconnectedness of life on Earth. Fundamental concepts of heredity and evolution provide a framework through inquiry-based instruction to explore the living world, the physical environment and the interactions within and between them.

Students engage in **investigations** to understand and explain the behavior of living things in a variety of scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

### SCIENCE INQUIRY AND APPLICATION

During the years of grades 9 through 12, all students must use the following scientific processes with appropriate **laboratory safety techniques** to construct their knowledge and understanding in all science content areas:

- Identify questions and concepts that guide scientific investigations;
- Design and conduct **scientific investigations**;
- Use technology and mathematics to improve investigations and communications;
- Formulate and revise explanations and models using logic and evidence (critical thinking);
- Recognize and analyze explanations and models; and
- Communicate and support a scientific argument.

## COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

### HEREDITY

- Cellular genetics
- Structure and function of DNA in cells
- Genetic mechanisms and inheritance
- Mutations
- Modern genetics

### EVOLUTION

- Mechanisms
  - Natural selection
  - Mutation
  - Genetic drift
  - Gene flow (immigration, emigration)
  - Sexual selection
  - History of life on Earth
- Diversity of Life
  - Speciation and biological classification based on molecular evidence
  - Variation of organisms within a species due to population genetics and gene frequency

### DIVERSITY AND INTERDEPENDENCE OF LIFE

- Classification systems are frameworks created by scientists for describing the vast diversity of organisms indicating the degree of relatedness between organisms.
- Ecosystems
  - Homeostasis
    - Carrying capacity
    - Equilibrium and disequilibrium

### CELLS

- Cell structure and function
  - Structure, function and interrelatedness of cell organelles
  - Eukaryotic cells and prokaryotic cells
- Cellular processes
  - Characteristics of life regulated by cellular processes o Photosynthesis, chemosynthesis, cellular respiration o Cell division and differentiation

BACK TO INDEX

BACK TO BIOLOGY OUTLINE

## CONTENT ELABORATION: HEREDITY

Building on knowledge from elementary school (plants and animals have life cycles and offspring resemble their parents) and knowledge from middle school (reproduction, Mendelian Genetics, inherited traits and diversity of species), this topic focuses on the explanation of genetic patterns of inheritance. In middle school, students learn that living things are a result of one or two parents, and traits are passed on to the next generation through both asexual and sexual reproduction. In addition, they learn that traits are defined by instructions encoded in many discrete genes and that a gene may come in more than one form called alleles.

At the high school level, the explanation of genes is expanded to include the following concepts:

- Life is specified by genomes. Each organism has a genome that contains all of the biological information needed to build and maintain a living example of that organism. The biological information contained in a genome is encoded in its deoxyribonucleic acid (DNA) and is divided into discrete units called genes.
- "**Genes** are segments of DNA molecules. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein. Inserting, deleting or substituting segments of DNA molecules can alter genes.
- An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm or have little or no effect on the offspring's success in its environments.
- **Gene mutations** (when they occur in gametes) can be passed on to offspring.
- Genes code for protein. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein.
- "**The many body cells** in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. Different genes are active in different types of cells, influenced by the cell's environment and past history." (AAAS)

In high school biology, Mendel's laws of inheritance (introduced in grade 8) are interwoven with current knowledge of DNA and chromosome structure and function to build toward basic knowledge of modern genetics. **Sorting** and recombination of genes in sexual reproduction and meiosis specifically result in a variance in traits of the offspring of any two parents and explicitly connect the knowledge to evolution.

The gene interactions described in middle school were limited primarily to dominance and co- dominance traits. In high school genetic mechanisms, both classical and modern including incomplete dominance, sex-linked traits, **goodness of fit test (Chi-square)** and dihybrid crosses are investigated through real-world examples. Dihybrid crosses can be used to explore linkage groups. Gene interactions and phenotypic effects can be introduced using real-world examples (e.g. **polygenic inheritance, epistasis,** and **pleiotrophy**).

It is imperative that the technological developments that lead to the current knowledge of heredity be included in the study of heredity. For example, the development of the model for DNA structure was the result of the use of technology and the studies and ideas of many scientists. Watson and Crick developed the final model, but did not do the original studies.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Develop a timeline from Mendel's, Darwin's and Wallace's work to the present day.
- Design and implement an investigation to test the affect of low doses of different common chemicals (e.g., boric acid, acetone or vinegar) on the development of a plant from seed to adult. Represent the data in a way that demonstrates the relationship, if any, between the chemical and changes in the development pattern. Explain how the investigation is similar to or different from the processes that occur in the natural environment.

**Note: Only plants should be used in this experiment.**

### INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The National Institute of the Health provides a **time line** of the milestones in genetics. Stories, archival images and original scientific publications tell the historical story of genetic discoveries. Students can trace how new understandings about the transmission of traits developed new questions that led to new discoveries. One major milestone is the Human Genome Project. **DNA Learning Center** features an interactive site that provides detailed background knowledge on how genomes are developed and used for research.
- Mendelian Genetics provides clear explanations for basic genetics; this link connects to an explanation and example of **Chi-square**.

BACK TO INDEX

BACK TO BIOLOGY OUTLINE

- Cold Spring Harbor Laboratory's **Dolan DNA Learning Center** provides DNA Molecules for models that help to illustrate some of the more abstract concepts associated with DNA. Scroll down the page to the *More 3-D Animation Library*.

### COMMON MISCONCEPTIONS

- **The Genetic Science Learning Center** provides information about misconceptions related to cloning.

### DIVERSE LEARNERS

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

### CLASSROOM PORTALS

The Annenberg Media series "**Teaching High School Science**" is a six-video program that highlights a variety of classroom activities that foster inquiry-based learning.

BACK TO INDEX

BACK TO BIOLOGY OUTLINE

## CONTENT ELABORATION: EVOLUTION

At the elementary school level, evolution concepts include the relationship between organisms and the environment, parent and offspring, and an introduction to the fossil record and extinction. At the middle school level, concepts include biodiversity (as part of biomes) and speciation, further exploration of the fossil record and Earth history, changing environmental conditions (abiotic factors), natural selection and biological evolution.

Biological evolution explains the natural origins for the diversity of life. Emphasis shifts from thinking in terms of selection of individuals with a particular trait to changing proportions of a trait in populations. The study of evolution must include Modern Synthesis, the unification of genetics and evolution and historical perspectives of evolutionary theory. The study of evolution must include gene flow, mutation, speciation, natural selection, genetic drift, sexual selection and Hardy Weinberg's law.

The basic concept of biological evolution is that the Earth's present-day species descended from earlier, common ancestral species. At the high school level, the term natural selection is used to describe the process by which traits become more or less common in a population due to consistent environmental effects upon the survival or reproduction of the individual with the trait. Mathematical reasoning must be applied to solve problems, (e.g., use Hardy Weinberg's law to explain gene frequency patterns in a population).

Modern ideas about evolution provide a natural explanation for the diversity of life on Earth as represented in the fossil record, in the similarities of existing species and in modern molecular evidence. From a long-term perspective, evolution is the descent with modification of different lineages from common ancestors.

Different phenotypes result from new combinations of existing genes or from mutations of genes in reproductive cells. At the high school level, the expectation is to combine grade-8 knowledge with explanation of the internal structure and function of chromosomes. Natural selection works on the phenotype.

**Populations evolve over time.** Evolution is the consequence of the interactions of:

1. The potential for a population to increase its numbers;
2. The genetic variability of offspring due to mutation and recombination of genes;
3. A finite supply of the resources required for life; and
4. The differential survival and reproduction of individuals with the specific phenotype.

Mutations are described in the content elaboration for Heredity. Apply the knowledge of mutation and genetic drift to real-world examples.

**Recent molecular**-sequence data generally, but not always, support earlier hypotheses regarding lineages of organisms based upon morphological comparisons.

Heritable characteristics influence how likely an organism is to survive and reproduce in a particular environment. When an environment changes, the survival value of inherited characteristics may change. This may or may not cause a change in species that inhabit the environment. Formulate and revise explanations for gene flow and sexual selection based on real-world problems.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Manipulate variables (e.g., distribution of traits, number of organisms and change in environmental conditions) in a simulation that represents natural selection in terms of how changes in environmental conditions can result in selective pressure on a population of organisms. Analyze the data to determine the relationship, if any, between the environmental changes and the population. Explain how each part of the simulation is similar to or different from the process of natural selection.

### INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **University of Colorado's PhET** provides an interactive simulation of natural selection for a population of rabbits. Environmental factors can be altered and mutations introduced to show how the population would change over time.
- Annenberg's Rediscovering Biology: **Molecular to Global Perspectives, Session 3,** Evolution and Phylogenetics is a tutorial for teachers on some of the current advances in biology.
- The National Science Teachers Association offers a position paper on the **Teaching of Evolution**.
- Online course in evolutionary biology for teachers is provided by the Public

BACK TO INDEX

BACK TO BIOLOGY OUTLINE

Broadcasting System: **Evolution**.

## COMMON MISCONCEPTIONS

- The University of California Museum of Paleontology with support provided by the National Science Foundation and the Howard Hughes Medical Institute provides **common misconceptions about evolution**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

The Annenberg Media series "**Teaching High School Science**" is a six-video program that highlights a variety of classroom activities that foster inquiry-based learning.

BACK TO INDEX

BACK TO BIOLOGY OUTLINE

## CONTENT ELABORATION: DIVERSITY AND INTERDEPENDENCE OF LIFE

**Building on knowledge** from elementary school (interactions of organisms within their environment and the law of conservation of matter and energy, food webs) and from middle school (flow of energy through organisms, biomes and biogeochemical cycles), this topic focuses on the study of diversity and similarity at the molecular level of organisms. Additionally the effects of physical/chemical constraints on all biological relationships and systems are investigated.

The great diversity of organisms and ecological niches they occupy result from more than 3.5 billion years of evolution. Some ecosystems can be reasonably persistent over hundreds or thousands of years. Like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. In the long run, however, ecosystems always change as geological or biological conditions vary. Misconceptions about population growth capacity, interspecies and intra-species competition for resources, and what occurs when a species immigrates to or emigrates from ecosystems are included in this topic. Technology must be used to access real-time/authentic data to study population changes and growth in specific locations.

Classification systems are frameworks developed by scientists for describing the diversity of organisms, indicating the degree of relatedness between organisms. **Recent molecular**-sequence data generally support earlier hypotheses regarding lineages of organisms based upon morphological comparisons. Both morphological comparisons and molecular evidence must be used to describe biodiversity (cladograms can be used to address this).

Organisms transform energy (flow of energy) and matter (cycles of matter) as they survive and reproduce. The cycling of matter and flow of energy occurs at all levels of biological organization, from molecules to ecosystems. At the high school level, the concept of energy flow as unidirectional in ecosystems is explored.

Mathematical graphing and algebraic knowledge (at the high school level) must be used to explain concepts of carrying capacity and homeostasis within biomes. Use real-time data to investigate population changes that occur locally or regionally. Mathematical models can include exponential growth model and the logistic growth model. The simplest version of the logistic growth model is **Population Growth Rate = rN (K-N) / K**; the only new variable added to the exponential model is K for carrying capacity.

**Note 1: Exponential growth equation in simplest form, change in population size *N* per unit time *t* is a product of *r* (the per capita reproductive rate) and *N* (population size.**

**Note 2: Carrying capacity is defined as the population equilibrium sized when births and deaths are equal; hence Population Growth Rate = zero.**

**Note 3: Constructing food webs/food chains to show interactions between organisms within ecosystems was covered in upper elementary school and middle school; constructing them as a way to demonstrate content knowledge is not appropriate for this grade. Students may use these diagrams to help explain real-world relationships or events within an ecosystem, but not to identify simple trophic levels, consumers, producers, predator-prey and symbiotic relations.**

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Construct a model to exemplify biomagnification in an ecosystem such as mercury in Lake Erie. Include a quantification of the distribution and buildup of the potentially damaging molecule that was introduced into the ecosystem. Within the model, predict and explain why the consequences occur at each trophic level as the relative concentration of the chemical increases. Include in your justification the changes in the number of organisms at each trophic level, matter cycling and energy transfer from one level to another.

### INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Examine **wildlife populations** in Ohio like bald eagles, beavers or white-tailed deer. The Ohio Department of Natural Resources provides population data over the years. Examine the factors that have impacted the carrying capacity.
- **The Southern Nevada Regional Professional Development Center** provides a tutorial, which explains the links between classification systems and evolution.

### COMMON MISCONCEPTIONS

- Binghamton University provides a general list for of naïve concepts for life science called **Overcoming Ecological Misconceptions**.

BACK TO INDEX

BACK TO BIOLOGY OUTLINE

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

The Annenberg Media series "**Teaching High School Science**" is a six-video program that highlights a variety of classroom activities that foster inquiry-based learning.

BACK TO INDEX

BACK TO BIOLOGY OUTLINE

## CONTENT ELABORATION: CELLS

**Building on knowledge** from middle school (cell theory), this topic focuses on the cell as a system itself (single-celled organism) and as part of larger systems (multicellular organism), sometimes as part of a multicellular organism, always as part of an ecosystem. The cell is a system that conducts a variety of functions associated with life. Details of cellular processes such as photosynthesis, chemosynthesis, cellular respiration, cell division and differentiation are studied at this grade level. Additionally, cellular organelles studied are cytoskeleton, Golgi complex and endoplasmic reticulum.

From about 4 billion years ago to about 2 billion years ago, only simple, single-celled microorganisms are found in the fossil record. Once cells with nuclei developed about a billion years ago, increasingly complex multicellular organisms evolved.

**Every cell is** covered by a membrane that controls what can enter and leave the cell. In all but quite primitive cells, a complex network of proteins provides organization and shape. **Within the cell** are specialized parts for the transport of materials, energy transformation, protein building, waste disposal, information feedback and movement. In addition to these basic cellular functions, most cells in multicellular organisms perform some specific functions that others do not.

**A living cell** is composed of a small number of elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur. Carbon, because of its small size and four available bonding electrons, can join to other carbon atoms in chains and rings to form large and complex molecules. The essential functions of cells involve chemical reactions that involve water and carbohydrates, proteins, lipids and nucleic acids. A special group of proteins, enzymes, enables chemical reactions to occur within living systems.

Cell functions are regulated. **Complex interactions** among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. **Most cells function** within a narrow range of temperature and pH. At very low temperatures, reaction rates are slow. High temperatures and/or extremes of pH can irreversibly change the structure of most protein molecules. Even small changes in pH can alter how molecules interact.

**The sequence** of DNA bases on a chromosome determines the sequence of amino acids in a protein. **Proteins catalyze** most chemical reactions in cells. Protein molecules are long, usually folded chains made from combinations of the 20 typical amino-acid sub-units found in the cell. The function of each protein molecule depends on its specific sequence of amino acids and the shape the chain takes as a result of that sequence.

**Note 1: The idea that protein molecules assembled by cells conduct the work that goes on inside and outside the cells in an organism can be learned without going into the biochemical details. It is sufficient for students to know that the molecules involved are different configurations of a few amino acids and that the different shapes of the molecules influence what they do.**

**Note 2: The concept of the cell and its parts as a functioning system is more important than memorizing parts of the cell.**

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Investigate the effect of different chemicals on the growth of algal colonies. Use mathematics to explain why even under ideal situations the colonies cannot continue exponential growth.
- Plan and design an investigation to determine the factors that affect the activity of enzymes on their substrates.
- Research and provide a written explanation of how unicellular organisms are used for industrial purposes.

### INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **Optical enhancements** can be used to alter the image produced by a light microscope to show greater detail. Compare cells using unaltered Compound Light Microscopes with the same cells using Darkfield, Rheinberg and Polarization techniques.
- Examine the role of bacteria in food production. Determine what types of bacteria are used and how it impacts (pH levels, gases produced, impact on proteins) the production of the product (yogurt, cheese).

#### Career Connection

Students can research careers in the field of food production relative to the role of bacteria across quality control, the **U.S. Food and Drug Administration**, agriculture, and research and development of food production (e.g., biologists; chemists; agricultural scientists; science technician; food processors, inspectors, and preparers). Through their research, they will identify applications of this classroom

BACK TO INDEX

BACK TO BIOLOGY OUTLINE

content to the workplace. Students can conduct career interviews, workplace visits, and navigate company or agency websites.

## COMMON MISCONCEPTIONS

- The Annenberg Media series *Minds of Our Own* offers *Lessons From Thin Air,* which illustrates the misconceptions that students have about photosynthesis and plant growth, at **http://www.learner.org/resources/series26.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

The Annenberg Media series "**Teaching High School Science**" is a six-video program that highlights a variety of classroom activities that foster inquiry-based learning.

BACK TO INDEX

# Chemistry

## SYLLABUS AND MODEL CURRICULUM

### COURSE DESCRIPTION

Chemistry is a high school level course, which satisfies the **Ohio Core** science graduation requirements of **Ohio Revised Code Section 3313.603**. This section of Ohio law requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

This course introduces students to key concepts and theories that provide a foundation for further study in other sciences as well as advanced science disciplines. Chemistry comprises a systematic study of the predictive physical interactions of matter and subsequent events that occur in the natural world. The study of matter through the exploration of classification, its structure and its interactions is how this course is organized.

Investigations are used to understand and explain the behavior of matter in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications. An understanding of leading theories and how they have informed current knowledge prepares students with higher order cognitive capabilities of evaluation, prediction and application.

### SCIENCE INQUIRY AND APPLICATION

During the years of grades 9 through 12, all students must use the following scientific processes with appropriate **laboratory safety techniques** to construct their knowledge and understanding in all science content areas:

- Identify questions and concepts that guide scientific investigations;
- Design and conduct **scientific investigations**;
- Use technology and mathematics to improve investigations and communications;
- Formulate and revise explanations and models using logic and evidence (critical thinking);
- Recognize and analyze explanations and models; and
- Communicate and support a scientific argument.

## COURSE CONTENT

The following topics may be taught in any order. There is no ODE-recommended sequence.

### STRUCTURE AND PROPERTIES OF MATTER

- Atomic structure
  - Evolution of atomic models/theory
  - Electrons
  - Electron configurations
- Periodic table
  - Properties
  - Trends
- Intramolecular chemical bonding
  - Ionic
  - Polar/covalent
- Representing compounds
  - Formula writing
  - Nomenclature
  - Models and shapes (Lewis structures, ball and stick, molecular geometries)
- Quantifying matter
- Phases of matter
- Intermolecular chemical bonding
  - Types and strengths
  - Implications for properties of substances
    - Melting and boiling point
    - Solubility
    - Vapor pressure

### INTERACTIONS OF MATTER

- Chemical reactions
  - Types of reactions
  - Kinetics
  - Energy
  - Equilibrium
  - Acids/bases
- Gas laws
  - Pressure, volume and temperature
  - Ideal gas law
- Stoichiometry
  - Molar calculations
  - Solutions
  - Limiting reagents
- Nuclear Reactions
  - Radioisotopes
  - Nuclear energy

BACK TO INDEX

BACK TO CHEMISTRY OUTLINE

## CONTENT ELABORATION: STRUCTURE AND PROPERTIES OF MATTER

### Atomic structure

The physical science syllabus included properties and locations of protons, neutrons and electrons, atomic number, mass number, cations and anions, isotopes and the strong nuclear force that hold the nucleus together. In this course, the **historical development of the atom** and the positions of electrons are explored in more detail.

Atomic models are constructed to explain experimental evidence and make predictions. The changes in the atomic model over time exemplify how scientific knowledge changes as new evidence emerges and how technological advancements like electricity extend the boundaries of scientific knowledge. Thompson's study of electrical discharges in cathode-ray tubes led to the discovery of the electron and the development of the plum pudding model of the atom. Rutherford's experiment, in which he bombarded gold foil with λparticles, led to the discovery that most of the atom consists of empty space with a relatively small, positively charged nucleus. Bohr used data from atomic spectra to propose a planetary model of the atom in which electrons orbit the nucleus, like planets around the sun. Later, Schrödinger used the idea that electrons travel in waves to develop a model in which electrons travel randomly in regions of space called orbitals (quantum mechanical model).

Based on the quantum mechanical model, it is not possible to predict exactly where electrons are located but there is a region of space surrounding the nucleus in which there is a high probability of finding an electron (electron cloud or orbital). **Data from atomic spectra (emission and absorption)** gives evidence that electrons can only exist at certain discrete energy levels and not at energies between these levels. Atoms are usually in the ground state where the electrons occupy orbitals with the lowest available energy. However, the atom can become excited when the electrons absorb a photon with the precise amount of energy (indicated by the frequency of the photon) to move to an orbital with higher energy. Any photon without this precise amount of energy will be ignored by the electron. The atom exists in the excited state for a very short amount of time. When an electron drops back down to the lower energy level, it emits a photon that has energy equal to the energy difference between the levels. The amount of energy is indicated by the frequency of the light that is given off and can be measured. Each element has a unique emission and absorption spectrum due to its unique electron configuration and specific electron energy jumps that are possible for that element. Being aware of the quantum mechanical model as the currently accepted model for the atom is important for science literacy as it explains and predicts subatomic interactions, but details should be reserved for more advanced study.

Electron energy levels consist of sublevels (s, p, d and f), each with a characteristic number and shape of orbitals. The shapes of d and f orbitals will not be assessed in high school. Orbital diagrams and electron configurations can be constructed to show the location of the electrons in an atom using established rules. However, the names of these rules will not be assessed. Valence electrons are responsible for most of the chemical properties of elements. In this course, electron configurations (extended and noble gas notation) and orbital diagrams can be shown for any element in the first three periods.

Although the quantum mechanical model of the atom explains the most experimental evidence, other models can still be helpful. Thinking of atoms as indivisible spheres is useful in explaining many physical properties of substances, such as the state (solid, liquid or gas) of a substance at room temperature. Bohr's planetary model is useful to explain and predict periodic trends in the properties of elements.

**Note: Quantum numbers and equations of de Broglie, Schrödinger and Plank are beyond the scope of this course.**

### Periodic Table

In the physical science syllabus, elements are placed in order of increasing atomic number in the periodic table such that elements with similar properties are placed in the same column. How the periodic table is divided into groups, families, periods, metals, nonmetals and metalloids also was in the physical science syllabus. In chemistry, with more information about the electron configuration of elements, similarities in the configuration of the valence electrons for a particular group can be observed. The electron configuration of an atom can be written from the position on the periodic table. The repeating pattern in the electron configurations for elements on the periodic table explain many of the trends in the properties observed. Atomic theory and bonding must be used to explain trends in properties across periods or down columns including atomic radii, ionic radii, first ionization energies, electronegativities and whether the element is a solid or gas at room temperature. Additional ionization energies, electron affinities and periodic properties of the transition elements, lanthanide and actinide series is reserved for more advanced study.

### Intramolecular Chemical Bonding

In the physical science syllabus, atoms with unpaired electrons tend to form ionic and covalent bonds with other atoms forming molecules, ionic lattices or network covalent structures. In this course, electron configurations, electronegativity values and energy considerations will be applied to bonding and the properties of materials with different types of bonding.

Atoms of many elements are more stable as they are bonded to other atoms. In such cases, as atoms bond, energy is released to the surroundings resulting in a system with lower energy. An atom's electron configuration, particularly the valence elections, determines how an atom interacts with other atoms. Molecules, ionic lattices and network covalent structures have different, yet predictable, properties

BACK TO INDEX

BACK TO CHEMISTRY OUTLINE

that depend on the identity of the elements and the types of bonds formed.

Differences in electronegativity values can be used to predict where a bond fits on the continuum between ionic and covalent bonds. The polarity of a bond depends on the electronegativity difference and the distance between the atoms (bond length). Polar covalent bonds are introduced as an intermediary between ionic and pure covalent bonds. The concept of metallic bonding also is introduced to explain many of the properties of metals (e.g., conductivity). Since most compounds contain multiple bonds, a substance may contain more than one type of bond. Compounds containing carbon are an important example of bonding, since carbon atoms can bond together and with other atoms, especially hydrogen, oxygen, nitrogen and sulfur, to form chains, rings and branching networks that are present in a variety of compounds, including synthetic polymers, fossil fuels and the large molecules essential to life. Detailed study of the structure of molecules responsible for life is reserved for more advanced courses.

### Representing Compounds

Using the periodic table, formulas of ionic compounds containing specific elements can be predicted. This can include ionic compounds made up of elements from groups 1, 2, 17, hydrogen and oxygen and polyatomic ions if given the formula and charge of the polyatomic ion. Given the formula, a compound can be named using conventional systems that include Greek prefixes and Roman numerals where appropriate. Given the name of an ionic or covalent substance, formulas can be written.

Many different models can be used to represent compounds including chemical formulas, Lewis structures, and ball and stick models. These models can be used to visualize atoms and molecules and to predict the properties of substances. Each type of representation provides unique information about the compound. Different representations are better suited for particular substances. Lewis structures can be drawn to represent covalent compounds using a simple set of rules and can be combined with valence shell electron pair repulsion (VSEPR) theory to predict the three-dimensional electron pair and molecular geometry of compounds. Lewis structures and molecular geometries will only be constructed for the following combination of elements: hydrogen, carbon, nitrogen, oxygen, phosphorus, sulfur and the halogens. Organic nomenclature is reserved for more advanced courses.

### Quantifying matter

In earlier grades, properties of materials were quantified with measurements that were always associated with some error. In this course, scientific protocols for quantifying the properties of matter accurately and precisely are studied. Using metric measuring systems, significant digits or figures, scientific notation, error analysis and dimensional analysis are vital to scientific communication.

There are three domains of magnitude in size and time: the macroscopic (human) domain, the cosmic domain and the submicroscopic (atomic and subatomic) domain. Measurements in the cosmic domain and submicroscopic domains require complex instruments and/or procedures.

Matter can be quantified in a way that macroscopic properties such as mass can reflect the number of particles present. Elemental samples are a mixture of several isotopes with different masses. The atomic mass of an element is calculated given the mass and relative abundance of each isotope of the element as it exists in nature. Because the mass of an atom is very small, the mole is used to translate between the atomic and macroscopic levels. A mole is used as a counting number, like a dozen. It is equal to the number of particles in exactly 12 grams of carbon – 12 atoms. The mass of one mole of a substance is equal to its formula mass in grams. The formula mass for a substance can be used in conjunction with Avogadro's number and the density of a substance to convert between mass, moles, volume and number of particles of a sample.

### Phases of Matter

In middle school, solids, liquids and gases were explored in relation to the spacing of the particles, motion of the particles and strength of attraction between the particles that make up the substance. In this course, plasmas and Bose-Einstein condensates also are included. Plasmas occur when gases have so much energy that the electrons are stripped away; therefore, they are electrically charged. In Bose-Einstein condensation the atoms, when subjected to temperatures a few billionths of a degree above absolute zero, all coalesce to lose individual identity and become a "super atom." Just as plasmas are super-hot atoms, Bose-Einstein condensates are the opposite – super-cold atoms (see **Note**). The forces of attraction between particles that determine whether a substance is a solid, liquid or gas at room temperature are addressed in greater detail with intermolecular chemical bonding later in the course.

**Note: The advancement of technology makes it possible to extend the boundaries of current knowledge and understanding. Consequently, Bose-Einstein condensates were only recently created in the laboratory (1995), although predicted more than 80 years ago. Detailed instruction of Bose-Einstein condensates or plasmas is not required at this grade level. This information is strictly for recognition that new discoveries are continually occurring, extending the realm of current understanding in science.**

### Intermolecular Chemical Bonding

In middle school, the concept of attractions between separate particles that hold molecules together in liquids and solids was introduced. These forces, called intermolecular attractions, are addressed in more detail in chemistry. Intermolecular attractions are generally weak when compared to intramolecular bonds, but span a wide range of strengths. The composition of a substance and the shape and polarity of a molecule are particularly important in determining the type and strength of bonding and intermolecular interactions. Types of intermolecular attractions include

BACK TO INDEX

BACK TO CHEMISTRY OUTLINE

London dispersion forces (present between all molecules), dipole-dipole forces (present between polar molecules) and hydrogen bonding (a special case of dipole-dipole where hydrogen is bonded to a highly electronegative atom such as fluorine, oxygen or nitrogen), each with its own characteristic relative strengths.

The configuration of atoms in a molecule determines the strength of the forces (bonds or intermolecular forces) between the particles and therefore the physical properties (e.g., melting point, boiling point, solubility, vapor pressure) of a material. For a given substance, the average kinetic energy (and therefore the temperature) needed for a change of state to occur depends upon the strength of the intermolecular forces between the particles. Therefore, the melting point and boiling point depend upon the amount of energy that is needed to overcome the attractions between the particles. Substances that have strong intermolecular forces or are made up of three- dimensional networks of ionic or covalent bonds tend to be solids at room temperature and have high melting and boiling points. Nonpolar organic molecules are held together by weak London dispersion forces. However, substances with longer chains provide more opportunities for these attractions and tend to have higher melting and boiling points. Increased branching of organic molecules interferes with the intermolecular attractions that lead to lower melting and boiling points.

Substances will have a greater solubility when dissolving in a solvent with similar intermolecular forces. If the substances have different intermolecular forces, they are more likely to interact with themselves than the other substance and remain separated from each other. Water is a polar molecule and it is often used as a solvent since most ionic and polar covalent substances will dissolve in it. In order for an ionic substance to dissolve in water, the attractive forces between the ions must be overcome by the dipole-dipole interactions with the water. Dissolving of a solute in water is an example of a process that is difficult to classify as a chemical or physical change and it is not appropriate to have students classify it one way or another.

Evaporation occurs when the particles with enough kinetic energy to overcome the attractive forces separate from the rest of the sample to become a gas. The pressure of these particles is called vapor pressure. Vapor pressure increases with temperature. Particles with larger intermolecular forces have lower vapor pressures at a given temperature since the particles require more energy to overcome the attractive forces between them. Molecular substances often evaporate more due to the weak attractions between the particles and can often be detected by their odor. Ionic or network covalent substances have stronger forces and are not as likely to volatilize. These substances often have little if any odor. Liquids boil when their vapor pressure is equal to atmospheric pressure.

In solid water, there is a network of hydrogen bonds between the particles that gives it an open structure. This is why water expands as it freezes and why solid water has a lower density than liquid water. This has important implications for life (e.g., ice floating on water acts as an insulator in bodies of water to keep the temperature of the rest of the water above freezing.)

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE

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

- Design an investigation to show that the volume of any liquid sample is constant when divided by its mass **(ACS Laboratory Assessment Activities).**
- Devise an investigation to show that the addition of a solute affects the density of a liquid **(ACS Laboratory Assessment Activities).**
- Investigate the volume of one drop of liquid from a Beral-type pipet. Devise a method. Defend the method with data and present it to a wider audience using multiple formats **(ACS Laboratory Assessment Activities)**.
- Investigate the variations and similarities between regular table sugar, high fructose corn syrup, Stevia, Aspartame (Equal®), saccharin (Sweet n' Low®), sucralose (Splenda®) and Agave. Draw a conclusion, based on data analysis regarding which compound is the most damaging for human consumption. Present your findings in multiple formats. Variation for this project could be made with oils (e.g., canola, coconut, olive, vegetable).
- Determine the percent by mass of water content in popcorn. Correlate its effect on the amount of popcorn produced (or time it takes to start the batch popping). Compare three brands, isolate other variables (e.g., popping method, use of different types of oil) and present findings in multiple formats (**http://faculty.coloradomtn.edu/jeschofnig/popcorn.htm**).
- Design an investigation to substantiate or negate the claims of a commercial product (e.g., ionic-tourmaline, a mineral that is said to emit quick-drying ions; a hair dryer; a shake weight dumbbell; a type of strong-bond glue). Determine function of, intent of and any potential bias with the product. Present findings in multiple formats.

BACK TO INDEX

BACK TO CHEMISTRY OUTLINE

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **Chem4Kids, University of Colorado at Boulder,** and **Scientific American** have articles and websites devoted to providing more information about Bose-Einstein condensates.
- "**Ultra Cold Atoms**" is an interview with a scientist who studies Bose-Einstein condensates. He describes the process needed to form Bose-Einstein condensates and the unusual properties of super-cooled matter.
- "**How Low Can You Go**" is an interactive simulation of the process by which substances can be cooled to absolute zero.
- **ACS Small-Scale Laboratory Assessment Activities** were prepared by Robert G. Silberman and Lucy T. Eubanks in association with the American Chemical Society Division of Chemical Education Examinations Institute in 1996 and provide excellent inquiry laboratory assessments. The Visions into Practice examples referenced above have been adapted from activities presented in this book.
- "**Alkali metals**" Discover the explosive results when water and alkali metals come together - and the science behind the reaction. Video.
- **The Periodic Table of Data** is an interactive periodic table. Students can select the properties they wish to view.
- **Atoms and Molecules** is a program produced by Annenberg that deals with teaching the very first steps of chemistry. It introduces the basic building blocks – the atoms – which, through their properties, periodicity and binding, form molecules.
- **Masterminding Molecules** seeks to develop logic and reinforce the principles of fair testing. It introduces the importance of concepts such as size, polarity and drug-like properties in the discovery of new medicines.

### Career Connection

Students will base their investigations (variations and similarities between regular table sugar, high fructose corn syrup, Stevia, Aspartame, saccharin, sucralose, and Agave) upon products produced by companies (e.g.: Heinz, Marzetti, Dannon). While researching the products and companies, they will also identify the professionals involved in similar processes within the companies and how they use chemistry in their work. Students will identify the connection between the classroom chemistry content and business practices relative to improving and modifying foods.

## COMMON MISCONCEPTIONS

- Students think volume and mass measure the same thing. (Minstrell, J., & Krause, P., n.d.)
- Students think big means the same thing as heavy. (Horton, 2007)
- Students think there are 100 $cm^3$ in 1 $m^3$.Horton, 2007)

Students often think that:

- Every different substance (e.g., $CO_2$, $H_2O$, salt) is made from atoms of that substance, not understanding that all substances come from the same set of elements assembled in different combinations.
- There is only one correct model of the atom.
- Electrons in an atom orbit nuclei like planets orbit the sun.
- Electron clouds are pictures of orbits.
- Electrons can be in any orbit they wish.
- Hydrogen is a typical atom.
- Electrons are physically larger than protons.
- Electrons and protons are the only fundamental particles.
- Physicists currently have the "right" model of the atom.
- Atoms can disappear (decay).
- Substances that are not hard and rigid cannot be solids (Stavy & Stachel, 1985).
- Chemists do not agree on how the "mole" should be defined: three meanings are that a mole is an individual unit of mass, a mole is a portion of substance and a mole is a number. Suggested (Kind, 2004) is that students be shown elements in a whole-number mass ratio, show that the ratio remains fixed regardless of the number of atoms, introduce the masses in grams, then introduce Avogadro's number while reinforcing atom size.
- Compounds with ionic bonds behave as simple molecules; instead, explore students' understanding of simple events like water boiling, sodium chloride and sugar dissolving, and ice melting. Make the events explicit by carrying them out in the students' presence and using molecular models to probe thinking about which bonds break and form (Kind, 2004).
- The first element in a formula is responsible for bond formation; instead, use cognitive conflict to show why atoms form different types of bonds and that atoms form compounds in the most energetically favorable way (Kind, 2004).
- Atoms "want" to form bonds; instead, use electrostatics to explain bond formation (Kind, 2004).
- There are only two types of bonds – covalent and ionic; instead, be consistent in using bonding terminology like "induced dipole-dipole bonds" and "permanent dipole-permanent dipole bonds because it is much more descriptive and clearly explains the kind of interaction involved (Kind, 2004).

BACK TO INDEX

BACK TO CHEMISTRY OUTLINE

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

**Macro to Micro Structures** is a program produced by Annenberg that deals with the conceptualization of micro processes and environments. It involves teaching chemistry through macro phenomena, which can be observed, and micro processes, which occur on the molecular level and can only be imagined.

BACK TO INDEX

BACK TO CHEMISTRY OUTLINE

## CONTENT ELABORATION: INTERACTIONS OF MATTER

### Chemical Reactions

In the physical science syllabus, coefficients were introduced to balance simple equations. Other representations including Lewis structures and three-dimensional models also were used and manipulated to demonstrate the conservation of matter in chemical reactions. In this course, more complex reactions will be studied, classified and represented with chemical equations and three-dimensional models. Classifying reactions into types can be a helpful organizational tool in recognizing patterns of what may happen when two substances are mixed (see **Note**). Some general types of chemical reactions are oxidation/reduction, synthesis, decomposition, single- replacement, double replacement (including precipitation reactions and some acid-base neutralizations) and combustion reactions. Some reactions can fit into more than one category. For example, a single replacement reaction also can be classified as an oxidation/reduction reaction. Identification of reactions involving oxidation and reduction as well as indicating what substance is being oxidized and what is being reduced are appropriate in this course. However, balancing complex oxidation/reduction reactions will be reserved for more advanced study.

Organic molecules release energy when undergoing combustion reactions and are used to meet the energy needs of society (e.g., oil, gasoline, natural gas) and to provide the energy needs of biological organisms (e.g., cellular respiration). When a reaction between two ionic compounds in aqueous solution results in the formation of a precipitate or molecular compound, the reaction often occurs because the new ionic or covalent bonds are stronger than the original ion-dipole interactions of the ions in solution. Laboratory experiences (3-D or virtual) with different types of chemical reactions must be provided.

**Note: Teachers should be aware that the common reaction classifications that are often used in high school chemistry courses often lead to misconceptions because they are not based on the actual chemistry, but on surface features that may be similar from one system to another (e.g., exchanging partners), even though the underlying chemistry is not the same. However, they may be useful in making predictions about what may happen when two substances are mixed.**

Reactions occur when reacting particles collide in an appropriate orientation and with sufficient energy. Not all collisions are effective. Stable reactants require the input of energy, the activation energy, to initiate a reaction. A catalyst provides an alternate pathway for a reaction, usually with a lower activation energy. With this lower energy threshold, more collisions will have enough energy to result in a reaction. An enzyme is a large organic molecule that folds into a unique shape by forming intermolecular bonds with itself. The enzyme's shape allows it to hold a substrate molecule in the proper orientation to result in an effective collision. The rate of a chemical reaction is the change in the amount of reactants or products in a specific period of time. Increasing the probability or effectiveness of the collisions between the particles increases the rate of the reaction. Therefore, changing the concentration of the reactants, the temperature or the pressure of gaseous reactants can change the reaction rate. Likewise, the collision theory can be applied to dissolving solids in a liquid solvent and can be used to explain why reactions are more likely to occur between reactants in the aqueous or gaseous state than between solids. The rate at which a substance dissolves should not be confused with the amount of solute that can dissolve in a given amount of solvent (solubility). Mathematical treatment of reaction rates are reserved for later study. Computer simulations can help visualize reactions from the perspective of the kinetic-molecular theory.

In middle school, the differences between potential and kinetic energy and the particle nature of thermal energy were introduced. For chemical systems, potential energy is in the form of chemical energy and kinetic energy is in the form of thermal energy. The total amount of chemical energy and/or thermal energy in a system is impossible to measure. However, the energy change of a system can be calculated from measurements (mass and change in temperature) from calorimetry experiments in the laboratory. Conservation of energy is an important component of calorimetry equations. Thermal energy is the energy of a system due to the movement (translational, vibrational and rotational) of its particles. The thermal energy of an object depends upon the amount of matter present (mass), temperature and chemical composition. Some materials require little energy to change their temperature and other materials require a great deal to change their temperature by the same amount. Specific heat is a measure of how much energy is needed to change the temperature of a specific mass of material a specific amount. Specific heat values can be used to calculate the thermal energy change, the temperature (initial, final or change in) or mass of a material in calorimetry. Water has a particularly high specific heat capacity, which is important in regulating Earth's temperature.

As studied in middle school, chemical energy is the potential energy associated with chemical systems. Chemical reactions involve valence electrons forming bonds to yield more stable products with lower energies. Energy is required to break interactions and bonds between the reactant atoms and energy is released when an interaction or bond is formed between the atoms in the products. Molecules with weak bonds (e.g., ATP) are less stable and tend to react to produce more stable products, releasing energy in the process. Generally, energy is transferred out of the system (exothermic) when the products have stronger bonds than the reactants and is transferred into the system (endothermic) when the reactants have stronger bonds than the products. Predictions of the energy requirements (endothermic or exothermic) of a reaction can be made given a table of bond energies. Graphic

BACK TO INDEX

BACK TO CHEMISTRY OUTLINE

representations can be drawn and interpreted to represent the energy changes during a reaction, including the activation energy. The roles of energy and entropy in determining the spontaneity of chemical reactions are dealt with conceptually in this course. Avoid describing entropy as the amount of disorder since this leads to persistent misconceptions. Mathematical treatment of entropy and its influence on the spontaneity of reactions is reserved for advanced study.

All reactions are reversible to a degree and many reactions do not proceed completely toward products but appear to stop progressing before the reactants are all used up. At this point, the amounts of the reactants and the products appear to be constant and the reaction can be said to have reached dynamic equilibrium. In fact, the reaction has stopped because the rate of the reverse reaction is equal to the rate of the forward reaction so there is no apparent change in the reaction. If given a graph showing the concentration of the reactants and products over the time of reaction, the equilibrium concentrations and the time at which equilibrium was established can be determined. Some reactions appear to proceed only in one direction. In these cases, the reverse reaction can occur but is highly unlikely (e.g., combustion reactions). Such reactions usually release a large amount of energy and require a large input of energy to go in the reverse direction. If a chemical system at equilibrium is disturbed by a change in the conditions of the system (e.g., increase or decrease in the temperature, pressure on gaseous equilibrium systems, concentration of a reactant or product), then the equilibrium system will respond by shifting to a new equilibrium state, reducing the effect of the change (Le Chatelier's Principle). If products are removed as they are formed during a reaction, then the equilibrium position of the system is forced to shift to favor the products. In this way, an otherwise unfavorable reaction can be made to occur. Mathematical treatment of equilibrium reactions is reserved for advanced study. Computer simulations can help visualize the progression of a reaction to dynamic equilibrium and the continuation of both the forward and reverse reactions after equilibrium has been attained.

Properties of acids and bases and the ranges of the pH scale were introduced in middle school. In chemistry, the structural features of molecules are explored to further understand acids and bases. Acids often result when hydrogen is covalently bonded to an electronegative element and is easily dissociated from the rest of the molecule to bind with water to form a hydronium ion ($H_3O^+$). The acidity of an aqueous solution can be expressed as pH, where pH can be calculated from the concentration of the hydronium ion. Bases are likely to dissociate in water to form a hydroxide ion. Acids can react with bases to form a salt and water. Such neutralization reactions can be studied quantitatively by performing titration experiments. Detailed instruction about the equilibrium of acids and bases and the concept of Brønsted-Lowry and Lewis acids and bases will not be assessed at this level.

### Gas laws

The kinetic-molecular theory can be used to explain the macroscopic properties of gases (pressure, temperature and volume) through the motion and interactions of its particles. When one of the three properties is kept constant, the relationship between the other two properties can be quantified, described and explained using the kinetic-molecular theory. Real-world phenomena (e.g., why tire pressure increases in hot weather, why a hot air balloon rises) can be explained using this theory. Problems also can be solved involving the changes in temperature, pressure and volume of a gas. When solving gas problems, the Kelvin temperature scale must be used since only in this scale is the temperature directly proportional to the average kinetic energy. The Kelvin temperature is based on a scale that has its minimum temperature at absolute zero, a temperature at which all motion theoretically stops. Since equal volumes of gases at the same temperature and pressure contain an equal number of particles (Avogadro's law), problems can be solved for an unchanging gaseous system using the ideal gas law ($PV = nRT$) where $R$ is the ideal gas constant (e.g., represented in multiple formats, 8.31 Joules / (mole K). The specific names of the gas laws are not addressed in this course. Deviations from ideal gaseous behavior are reserved for more advanced study. Explore the relationships between the volume, temperature and pressure in the laboratory or through computer simulations or virtual experiments.

### Stoichiometry

A stoichiometric calculation involves the conversion from the amount of one substance in a chemical reaction to the amount of another substance. The coefficients of the balanced equation indicate the ratios of the substances involved in the reaction in terms of both particles and moles.

Once the number of moles of a substance is known, amounts can be changed to mass, volume of a gas, volume of solutions and/or number of particles. Molarity is a measure of the concentration of a solution that can be used in stoichiometric calculations. When performing a reaction in the lab, the experimental yield can be compared to the theoretical yield to calculate percent yield. The concept of limiting reagents is treated conceptually and not mathematically. Molality and Normality are concepts reserved for more advanced study.

### Nuclear Reactions

The basics of nuclear forces, isotopes, radioactive decay, fission and fusion were addressed in the physical science syllabus. In chemistry, specific types of radioactive decay and using nuclear reactions as a source of energy are addressed. Radioactive decay can result in the release of different types of radiation (alpha, beta, gamma, positron) each with a characteristic mass, charge and potential to ionize and

BACK TO INDEX

BACK TO CHEMISTRY OUTLINE

penetrate the material it strikes. Beta decay results from the decay of a neutron and positron decay results from the decay of a proton. When a radioisotope undergoes alpha, beta or positron decay, the resulting nucleus can be predicted and the balanced nuclear equation can be written.

Nuclear reactions, such as fission and fusion, are accompanied by large energy changes that are much greater than those that accompany chemical reactions. These nuclear reactions can theoretically be used as a controlled source of energy in a nuclear power plant. There are advantages and disadvantages of generating electricity from fission and fusion.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE

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

- Devise an investigation, given five numbered samples of either acidic or basic solution and a sixth solution sample of phenolphthalein. Rank the samples in order of their concentration. Present methodology and results in multiple formats (adapted, Silberman, 1996).
- Design an investigation to determine the most effective antacid per gram for neutralizing stomach acid (HCl), baking soda ($NaHCO_3$) or magnesium hydroxide ($Mg(OH)_2$).
- No nuclear waste generated over the last 40 years has been permanently disposed. Determine the time required for a rock (uranium-238) with a rate constant for decay ($4.5 \times 10^9$ years) to decompose to safe levels. Propose a method for containing this material until safe levels are achieved.

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- **Teaching Entropy Analysis in the First Year Chemistry Class and Beyond** is an article that appeared in the Journal of Chemistry Education that discusses scientifically accurate ways to teach entropy to high school students. The sections from the beginning of the article to the bottom of page 1586, ending at ***Advanced Students*** is appropriate for the level of this chemistry course.
- **Indicators in Chemistry** is a teacher tube video that shows how the content of acids and bases can be integrated into a technological design activity.
- The Design Studio introduces the concepts of shape, enzyme inhibition, potency, drug-like properties and the need to achieve a balance of properties to discover effective medicines.
- **Oil strike** is an interactive, chemistry-themed game. Try and maximize your profits as you build your own refineries.

## COMMON MISCONCEPTIONS

- Acids can burn and eat material away (Kind, 2004); introduce acids and bases alongside each other.
- Neutralization means an acid breaking down (Kind, 2004); show the difference between "strong" and "weak" and diluted and concentrated.
- A base/alkali inhibits the burning properties of an acid (Kind, 2004); introduce neutralization as a reaction involving an acid and a base reacting together.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

**Energetics and Dynamics** is a video-on-demand produced by Annenberg that emphasizes the importance of learning about energetics and dynamics in order to improve students' understanding of basic principles of chemistry.

BACK TO INDEX

# Environmental Science

## SYLLABUS AND MODEL CURRICULUM

### COURSE DESCRIPTION

Environmental science is a high school level course, which satisfies the **Ohio Core** science graduation requirements of **Ohio Revised Code Section 3313.603**. This section of Ohio law requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

Environmental science incorporates biology, chemistry, physics and physical geology and introduces students to key concepts, principles and theories within environmental science.

Investigations are used to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications. It should be noted that there are classroom examples in the model curriculum that can be developed to meet multiple sections of the syllabus, so one well-planned long-term project can be used to teach multiple topics.

### SCIENCE INQUIRY AND APPLICATION

During the years of grades 9 through 12, all students must use the following scientific processes with appropriate **laboratory safety techniques** to construct their knowledge and understanding in all science content areas:

- Identify questions and concepts that guide scientific investigations;
- Design and conduct **scientific investigations**;
- Use technology and mathematics to improve investigations and communications;
- Formulate and revise explanations and models using logic and evidence (critical thinking);
- Recognize and analyze explanations and models; and
- Communicate and support a scientific argument.

## COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

### EARTH SYSTEMS: INTERCONNECTED SPHERES OF EARTH

- Biosphere
  - Evolution and adaptation in populations
  - Biodiversity
  - Ecosystems (equilibrium, species interactions, stability)
  - Population dynamics
- Atmosphere
  - Atmospheric properties and currents
- Lithosphere
  - Geologic events and processes
- Hydrosphere
  - Oceanic currents and patterns (as they relate to climate)
  - Surface and ground water flow patterns and movement
  - Cryosphere
- Movement of matter and energy through the hydrosphere, lithosphere, atmosphere and biosphere
  - Energy transformations on global, regional and local scales
  - Biogeochemical cycles
  - Ecosystems
  - Climate and weather

### EARTH'S RESOURCES

- Energy resources
  - Renewable and nonrenewable energy sources and efficiency
  - Alternate energy sources and efficiency
  - Resource availability
  - Mining and resource extraction
- Air and air pollution
  - Primary and secondary contaminants
  - Greenhouse gases
  - Clean Air Act
- Water and water pollution
  - Potable water and water quality
  - Hypoxia, eutrophication
  - Clean Water Act
  - Point source and non-point source contamination
- Soil and land
  - Desertification
  - Mass wasting and erosion
  - Sediment contamination

BACK TO INDEX

- Land use and land management (including food production, agriculture and zoning)
- Solid and hazardous waste

- Wildlife and wilderness
  - Wildlife and wilderness management
    - Endangered species

## GLOBAL ENVIRONMENTAL PROBLEMS AND ISSUES

- Human population
- Potable water quality, use and availability
- Climate change
- Sustainability
- Species depletion and extinction
- Air quality
- Food production and availability
- Deforestation and loss of biodiversity
- Waste management (solid and hazardous)

BACK TO INDEX

BACK TO ENVIRONMENTAL SCIENCE OUTLINE

## CONTENT ELABORATION: EARTH SYSTEMS

This topic builds upon both the physical science and biology courses as they relate to energy transfer and transformation, conservation of energy and matter, evolution, adaptation, biodiversity, population studies, and ecosystem composition and dynamics. In grades 6-8, geologic processes, biogeochemical cycles, climate, the composition and properties of the atmosphere, lithosphere and hydrosphere (including the hydrologic cycle) are studied.

The focus for this topic is on the connections and interactions between Earth's spheres (the hydrosphere, atmosphere, biosphere and lithosphere). Both natural and human-made interactions must be studied. This includes an understanding of causes and effects of climate, global climate (including el Niño/la Niña patterns and trends) and changes in climate through Earth's history, geologic events (e.g., a volcanic eruption or mass wasting) that impact Earth's spheres, biogeochemical cycles and patterns, the effect of abiotic and biotic factors within an ecosystem, and the understanding that each of Earth's spheres is part of the dynamic Earth system. Ground water and surface water velocities and patterns are included as the movement of water (either at the surface, in the atmosphere or beneath the surface) can be a mode of transmission of contamination. This builds upon previous hydrologic cycle studies in earlier grades. Geomorphology and topography are helpful in determining flow patterns and pathways for contamination.

The connections and interactions of energy and matter between Earth's spheres must be researched and investigated using actual data. The emphasis is on the interconnectedness of Earth's spheres and the understanding of the complex relationships between each, including both abiotic and biotic factors. One event, such as a petroleum release or a flood, can impact each sphere. Some impacts are long- term, others are short-term and most are a combination of both long- and short-term. It is important to use real, quantifiable data to study the interactions, patterns and cycles between Earth's spheres.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Choose a specific location in the United States. Research and analyze the patterns of climate change throughout the geologic record, historic data (human records) and present-day data for the location. Be able to explain the interpretation and analysis of the data. Create a graphical representation of the pattern and discuss with the class.
- Research or investigate an actual environmental/geologic event (e.g., a specific release of a toxin/contaminant, hurricane, earthquake, flood, fire or landslide) and determine how each of Earth's spheres was impacted. Long-term and short-term impacts must be included. Provide scientific evidence and data to support conclusions and trace movement of contamination or energy through each sphere. Use a multimedia presentation to share findings with the class.
- Research an actual contamination event (that has quantitative data available). Use a computer-modeling program (many are available through freeware sites, fate and transport modeling) to model and predict the movement of the contamination through Earth's spheres. Develop and evaluate solutions for the cleanup, containment or reduction of the contamination. Include consequences and/or alternatives for the proposed solution. Present findings to the class or an authentic audience.
- Plan and implement an experiment or demonstration to illustrate the factors that lead to changing oceanic currents (both deep and shallow, can be 3-D or virtual). Document all steps and prepare a presentation or a poster session for the class. Defend the process and the results.
- Plan and implement an investigation to explore biomagnification or bioaccumulation within a specific Ohio ecosystem (existing public case studies can be used, such as a local Brownfields case – see resource listed below). Document the steps and process to collect or research, evaluate or test and analyze the data. Research should include the possible impact to humans. Present the process and results to the class verbally or in writing.
- Choose a specific living species. Using scientific data, trace the history of that species. Show existing, proven evolutionary relationships, environmental (both biotic and abiotic) requirements, global locations, ecosystem characteristics and sustainability predictions. Use quantifiable data to support findings and present findings to the class orally, through demonstration/explanation or a poster session.
- Plan and implement a population study of a specific area (over a period of time) or critique/analyze an existing population study. Document changes in weather, food availability and any change to the population. Prepare a scientific analysis and conclusion (in writing) for the study.
- Research or conduct a field investigation for a specific invasive species that is present in the local community or in Ohio. Examples of research questions

BACK TO INDEX

BACK TO ENVIRONMENTAL SCIENCE OUTLINE

include: *How did the organism get into Ohio? What is being done to control the spread of the species? What is the impact of the species on the native population?* Use quantifiable data to draw conclusions and present research results in writing or orally.

- Investigate and research the effect that climate change is having or has had on a specific living or extinct species, such as the harp seal or elkhorn coral, or on an ecosystem, such as the Great Barrier Reef or the Arctic Circle.
- Research and analyze quantifiable scientific data pertaining to food availability, reproductive requirements and changes, adaptations or population changes to draw conclusions. Students present data and conclusions to the class.

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The University of Maine offers a scientific case study of a specific glacier, including quantifiable data that documents measurable changes each year, at **http://climatechange.umaine.edu/Research/projects/byrdglacier.html**.
- The OSU Byrd Polar Research site offers numerous educational resources that are related to glacial geology and climate change at **http://bprc.osu.edu/**.
- The Ohio EPA provides a map of all regional Brownfields projects, a resource to provide data and documentation for local case studies involving a variety of hazardous releases into the environment and quantifiable data and monitoring data at **http://www.epa.state.oh.us/derr/SABR/brown_dtb/browndtb.aspx**.
- The North Carolina Department of Environment and Natural Resources offers basic hydrology background information, including ways to calculate ground water velocity and outlining different types of aquifers, to help in teaching about ground water at **http://www.ncwater.org/Education_and_Technical_Assistance/Ground_Water/Hydrogeology/**.
- Intellicast.com offers real-time data for the jet stream (updated daily), including velocities and patterns on an isometric map at **http://www.intellicast.com/National/Wind/JetStream.aspx**.
- The College Board provides enduring understandings recommended for AP environmental science, which can help to form discussion questions and research for this topic at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**. Appendix A (page 175) of this document contains the environmental science information.
- The Digital Library for Earth Systems Education offers resources from a number of sources, such as *National Geographic*, government agencies and other scientific agencies. Resources are searchable by grade level and standards at **http://www.dlese.org/library/index.jsp**.
- NOAA provides real-time data for many of its projects and research missions at **http://www.noaa.gov/sciencemissions/bpoilspill.html**.
- The Ohio Department of Natural Resources' Project Wet offers training and resources for K-12 teachers that promote deep understanding about all aspects of water and the interconnectedness of all of Earth's spheres (Earth Systems). Training and workshop opportunities can be found at **http://www.dnr.state.oh.us/tabid/3501/Default.aspx**.
- Project Wet's *Healthy Water, Healthy People* water quality educators guide offers ideas and resources for teaching all aspects of water and water contamination issues. Ideas for field monitoring, research projects and student investigations as well as teacher training are available at **http://www.projectwet.org/water-resources-education/water-quality-education/**.
- EarthComm offers a program that uses many different strategies to reach students of all learning levels at **http://www.agiweb.org/earthcomm/**. The teaching of environmental science through relating the classroom to the real world is essential for many learners.
- The National Academy of Science provides a number of resources related to climate change and greenhouse gases at **http://nas-sites.org/americasclimatechoices/**. Some of the options include Web quests, virtual/digital learning, virtual fieldtrips and field research ideas. By providing alternate options and choices that can be completed by students at different paces, all students can benefit.

## COMMON MISCONCEPTIONS

- The NSTA offers a position paper which is helpful in addressing concerns and misconceptions from students regarding evolution at **http://www.nsta.org/about/positions/evolution.aspx**.
- Students may have difficulty separating science from non-science factors as they relate to the different parts of the environment. It is important to distinguish "what is science" and therefore, what will be included in an environmental science class, especially as it relates to climate change and evolution. Identifying and understanding personal bias and ethical issues are an important step in recognizing science. Wheaton College offers *Teaching Ethical Analysis in Environmental Management Decisions: A Process-Oriented Approach* at **http://www.wheaton.edu/~/media/Files/Academics/Departments/Biology/Van Dyke files/Teachingethical.pdf**
- The EPA provides support for teachers that are teaching about climate change. To address student misconceptions regarding this issue, it is important to use real-time data and research, which can be found through the EPA at **http://www.epa.gov/students/teachers.html#epaclimate**

BACK TO INDEX

BACK TO ENVIRONMENTAL SCIENCE OUTLINE

- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

BACK TO INDEX

BACK TO ENVIRONMENTAL SCIENCE OUTLINE

## CONTENT ELABORATION: EARTH'S RESOURCES

This topic explores the availability of Earth's resources, extraction of the resources, contamination problems, remediation techniques and the storage/disposal of the resources or by-products. Conservation, protection and sustainability of Earth's resources also are included. This builds upon grades 6-8 within the Earth and Space Science strand (sections pertaining to energy and Earth's resources) and the biology and physical science (in particular chemistry and energy topics) courses at the high school level.

To understand the effects that certain contaminants may have on the environment, scientific investigations and research must be conducted on a local, national and global level. Water, air, land, and biotic field and lab sampling/testing equipment and methods must be utilized with real-world application. Quantifiable field and/or lab data must be used to analyze and draw conclusions regarding air, water or land quality. Examples of types of water-quality testing include: hydraulic conductivity, suspended and dissolved solids, dissolved oxygen, biochemical oxygen demand, temperature, pH, fecal coliform and macro-invertebrate studies. Wetland or woodland delineations and analysis, land use analysis and air monitoring (e.g., particulate matter sizes/amount) are all appropriate field study investigations. Comparative analysis of scientific field or lab data should be used to quantify the environmental quality or conditions. Local data also can be compared to national and international data.

The study of relevant, local problems can be a way to connect the classroom to the real world. Within Ohio, there are numerous environmental topics that can be investigated. Examples include wetland loss or mitigation, surface or ground water contamination (including sediment, chemical or thermal contamination), acid rain, septic system or sewage overflows/failures, landfill seepage, underground storage tank/pipe releases, deforestation, invasive species, air pollution (e.g., photochemical smog or particulate matter), soil loss/erosion or acid mine drainage.

At the advanced science level, renewable and nonrenewable energy resources topics investigate the effectiveness, risk and efficiency for differing types of energy resources at a local, state, national and global level. This builds upon grades 6-8 within both Earth and Space Science, and physical science at the high school level. Nuclear and geothermal energy are included in this topic.

Feasibility, availability, remediation and environmental cost are included in the extraction, storage, use and disposal of both abiotic and biotic resources. Environmental impact must be evaluated as it pertains to both the environmental and human risk. Examples include chemical hazards, radiation, biological hazards, toxicology and risk analysis studies. Learning about conservation and protection of the environment also requires an understanding of laws and regulations that exist to preserve resources and reduce and/or remediate contamination, but the emphasis should be on the science behind the laws and regulations.

Relating Earth's resources to a global scale and using technology to collect global resource data for comparative classroom study is recommended. In addition, it is important to connect the industry and the scientific community to the classroom to increase the depth of understanding. Critical thinking and problem-solving skills are important in evaluating resource use, management and conservation. New discoveries and research are important parts of this topic.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Choose a specific environmental problem, such as the effect of herbicides in water (e.g., Atrizine), an invasive species (e.g., purple loosestrife or the Asian carp) or carbon monoxide in the atmosphere, and research the history, the scientific data before and after relevant laws were passed, and how this problem is being addressed in other countries/globally. Computer models or programs can be used to predict/analyze the problem or the movement of the contamination. Present scientific evidence and quantifiable data orally, through a poster session or in written form (scientific research paper).
- Design and conduct a field investigation that concentrates on a specific environmental problem (e.g., sediment contamination or acid mine drainage) and how the problem can be remediated. Compare results to similar communities, recommended limits, permit requirements or other published results. Analyze the data and make specific recommendations to limit, remediate, reduce or prevent the problem. Present findings to an authentic audience from the community.
- Research and document land-use planning or management in the community or at a specific location. Attend community meetings pertaining to land-use, land-management or zoning plans. Research questions should include: ***What factors are used in determining use? What data is collected and analyzed? What changes are on the horizon?*** Discuss in class.
- Take a field trip to visit the water treatment facility or watch the drilling of a water well. Document observations, including information about how water is treated prior to and after use, specific issues that may impact the source, the location of the original water source, specific tests conducted (materials and methods needed to test and how the tests are conducted, results of the tests), and the steps taken to monitor the water at the source and throughout the process (including from the facility/well into the residence). Discuss with the class.

BACK TO INDEX

BACK TO ENVIRONMENTAL SCIENCE OUTLINE

- Using real-time data, research the most severe environmental problems (and the root causes for the problems) that face the local community, Ohio, the United States or the world. Present evidence (quantitative data) and conclusions orally, through a poster session or in written form (scientific research paper).
- Research and collect specific data for a mass wasting or desertification event (can be present day or historical). Research questions should include: *What factors led to the event? What was the result of the event (how was each of Earth's spheres impacted)? What data is present (analyze the data and draw conclusions)? What laws are related to the event? How can this be prevented in the future?* Record the results graphically or in a scientific report.

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The U.S. Geological Survey outlines current surface water projects within the state of Ohio. Surface water-quality data (including stream gauge and volume data) can be found and used to support local field investigations. There also are links to provide historic surface and ground water data for analysis, at **http://oh.water.usgs.gov/data.htm**
- The U.S. Environmental Protection Agency offers a risk-assessment information system with specific Ohio risk assessments that can be used to provide background data or specific case studies. This information helps illustrate the types of tests that are included in a risk assessment and also provides different risk levels for specific contaminants. Find it at **http://rais.ornl.gov/tutorials/whatisra.html**
- The U.S. EPA houses online computer-modeling program for air pollutants. There also are resources and data explaining the use of computer modeling and air pollution that may be helpful in student research and investigation projects. Find it at **http://www.epa.gov/scram001/aqmindex.htm**.
- ODNR's website discusses acid mine drainage issue in Ohio. There also are specific links to Ohio watersheds (including maps of the watershed locations) that are in the abatement program and water quality data to study changes within a local area. Find it at **http://minerals.ohiodnr.gov/**
- The Ohio EPA offers a discussion about Ohio wetlands and the delineation, and qualitative analysis of Ohio wetlands at **http://www.epa.state.oh.us/portals/47/facts/ohio_wetlands.pdf**.
- The Ohio EPA outlines federal and state environmental laws at **http://www.epa.state.oh.us/Rules_and_Laws.aspx**.
- The Digital Library for Earth Systems Education offers resources from a number of sources, such as *National Geographic*, government agencies and other scientific agencies. Grade 9-12 resources are provided at **http://www.dlese.org/library/query.do?q=&s=0&gr=02**.
- The Solid Waste Authority of Central Ohio resource section offers ideas about landfill tours, classroom and kids activities and teacher assistance and resources. **http://www.swaco.org/Education.aspx**
- *Science News* and *Science Daily* offer information highlighting science in the news that can be used for class discussions. The information is updated weekly or bi-weekly and provides references and resource sites for more in-depth discussion. Visit **http://www.sciencenews.org/** and **http://www.sciencedaily.com/**.
- NOAA provides real-time data for many of its projects and research missions at **http://www.noaa.gov/sciencemissions/bpoilspill.html**.
- For an index page for numerous environmental educational resources available through the Ohio EPA and associated agencies, visit **http://www.epa.state.oh.us/oeef/ee_resources.aspx**.
- Geology.com provides information on current events in all topic areas of geology, including resources and uses of resources, at **http://geology.com/**.
- The Ohio Department of Natural Resources provides data regarding sustainable water programs that are conducted in Ohio (monitoring programs, water quality testing information and contact information for the ODNR scientists that work in these areas) at **http://ohiodnr.com/tabid/18951/Default.aspx**.
- NSTA provides learning modules called "SciPacks" that are designed to increase teacher content knowledge through inquiry-based modules. Find a module addressing Earth's resources and humans at **http://learningcenter.nsta.org/products/scipacks.aspx**.
- The Ohio Department of Natural Resources' Project Wet offers training and resources for K-12 teachers that promote deep understanding about all aspects of water and the interconnectedness of all of Earth's spheres (Earth systems). Training and workshop opportunities can be found at **http://www.dnr.state.oh.us/tabid/3501/Default.aspx**.
- The College Board provides enduring understandings recommended for AP environmental science which can help to form discussion questions and research for this topic at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**. Appendix A (page 175) of this document contains the environmental science information.
- Project Wet's *Healthy Water, Healthy People* water quality educators guide offers ideas and resources for teaching all aspects of water and water contamination issues. Ideas for field monitoring, research projects and student investigations as well as teacher training are available at **http://www.projectwet.org/water-resources-education/water-quality-education/**.

BACK TO INDEX

BACK TO ENVIRONMENTAL SCIENCE OUTLINE

**Career Connection**

Students will research careers related to environmental science (e.g., environmental engineer, hydrogeologist, water treatment plant operator, inspector, technician). Then, they will visit a water treatment facility and conduct career interviews to gather information about the various careers and their roles at the plant. Students will apply the information to their plan for education and training through high school and beyond.

## COMMON MISCONCEPTIONS

- Common misconceptions dealing with renewable energy efficiency along with suggestions to overcome these misconceptions through exploration and investigation are available on the website of California State University, Northridge, at **http://www.csun.edu/~ml727939/coursework/690/Miha's misconception report.doc**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

BACK TO INDEX

BACK TO ENVIRONMENTAL SCIENCE OUTLINE

## CONTENT ELABORATION: GLOBAL ENVIRONMENTAL PROBLEMS AND ISSUES

This topic is a culminating section that incorporates the previous topics and applies them to a global or international scale. Case studies, developing and using models, collecting and analyzing water and/or air quality data, conducting or researching population studies and methods of connecting to the real world must be emphasized for this topic. Technology can be used for comparative studies to share local data internationally so that specific, quantifiable data can be compared and used in understanding the impact of some of the environmental problems that exist on a global scale. Researching and investigating environmental factors on a global level contributes to the depth of understanding by applying the environmental science concepts to problem solving and design. Examples of global topics that can be explored include building water or air filtration models, investigating climate change data, monitoring endangered or invasive species, and studying the environmental effects of increasing human population. Researching contemporary discoveries, new technology and new discoveries can lead to improvement in environmental management.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Investigate and research global human population patterns and changes over time. Example research questions include: ***What countries have marked changes in populations at present, in the past? What are the factors that affect population change? What are verifiable relationships related to population (e.g., economic indicators, education levels, laws, resource availability, environmental conditions)?*** Provide evidence and data to support conclusions. Document the research in a scientific research paper.
- Investigate and/or research (using quantifiable data and evidence) the relationship between deforestation and changing weather or, in some cases, climate, at a specific location (like the Amazon region of South America). Analyze the data and draw a conclusion based upon the analysis. Discuss the conclusion with the class.
- Plan and implement an investigation to determine the water quality of a section of a local stream. This includes researching and conducting standard water-quality tests and how to analyze the results. Compare the results to known data from a different country (with a similar setting). Compare and contrast the data and analyze the results. Example research questions include: ***What are the reasons for any statistically significant differences? What comparisons can be made about the topography or geomorphology of the location? What testing methods, materials and/or equipment are used? What are the testing dates/times/locations? What are the existing, applicable, environmental laws or requirements?*** Document all results and present to an authentic audience.
- Develop a risk assessment for a specific company. Research one particular toxin or hazardous chemical used by the company (e.g., diesel fuel) to determine possible risks and pathways to the environment and humans. The assessment should include: nature of the toxin/chemical (e.g., is the material flammable, does is react when wet), on-site use and handling (including existing safety practices) of the toxin/chemical, by-products (e.g., vapors or dilution processes), storage, transportation of the toxin/chemical, required documentation, emergency plans/guidelines, topography and geology of the area. Use a computer-modeling program (many are available through freeware sites) to model and predict the movement of the possible pathways of the toxin/chemical and recommendations of methods to contain the release of the toxin/chemical. Present the findings to the class or an authentic audience.

### INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The Ohio Department of Natural Resources provides data regarding sustainable water programs that are conducted in Ohio (monitoring programs, water quality testing information and contact information for the ODNR scientists that work in these areas) at **http://ohiodnr.com/tabid/18951/Default.aspx**.
- The U.S. Environmental Protection Agency offers a risk-assessment information system with specific Ohio risk assessments that can be used to provide background data or specific case studies. This information helps illustrate the types of tests that are included in a risk assessment and also provides different risk levels for specific contaminants. Find it at **http://rais.ornl.gov/.**
- The Ohio EPA provides guidance for ecological risk assessment, including all types of monitoring and data requirements, that can be used to provide an authentic learning experience for students. Parts of the requirements can be modified and simplified for high school students, including examples of the level of detail required to determine human risk and site evaluation. Find this information at **http://www.epa.ohio.gov/portals/30/rules/RR-031.pdf**.

BACK TO INDEX

BACK TO ENVIRONMENTAL SCIENCE OUTLINE

- The Environmental Protection Agency provides helpful information about conducting risk assessments at **http://www.epa.gov/risk/.**
- For information about the use of fate and transport modeling in tracing the movement of hazardous materials/contamination, including links to educational fate and transport programs and some freeware that may assist in demonstrations or small student investigations, visit **http://ceenve3.civeng.calpoly.edu/cota/enve436/fate.html**.
- The U.S. Geological Survey provides a list of free software downloads that apply directly to modeling of surface and/or groundwater at **http://water.usgs.gov/software/lists/general/**.
- *Science News* and *Science Daily* offer information highlighting science in the news that can be used for class discussions. The information is updated weekly or bi-weekly and provides references and resource sites for more in-depth discussion. Visit **http://www.sciencenews.org/** and **http://www.sciencedaily.com/**.
- NOAA provides real-time data for many of its projects and research missions at **http://www.noaa.gov/sciencemissions/bpoilspill.html**.
- The College Board provides enduring understandings recommended for AP environmental science that can help to form discussion questions and research at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**. Appendix A (page 175) of this document contains the environmental science information.
- The Ohio Department of Natural Resources' Project Wet offers training and resources for K-12 teachers that promote deep understanding about all aspects of water and the interconnectedness of all of Earth's spheres (Earth systems). Training and workshop opportunities can be found at **http://www.dnr.state.oh.us/tabid/3501/Default.aspx**.
- Project Wet's *Healthy Water, Healthy People* water quality educators guide offers ideas and resources for teaching all aspects of water and water contamination issues. Ideas for field monitoring, research projects and student investigations as well as teacher training are available at **http://www.projectwet.org/water-resources-education/water-quality-education/**.

## COMMON MISCONCEPTIONS

- Students may have misinformation and misconceptions that pertain to climate change. To address this, it is important to provide evidence of climate change throughout Earth's history and current data to document temperature changes (surface and oceanic). Data and other resources to help with teaching climate change can be found at **http://www.epa.gov/climatechange/index.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

BACK TO INDEX

# Physical Geology

## SYLLABUS AND MODEL CURRICULUM

### COURSE DESCRIPTION

Physical geology is a high school level course, which satisfies **Ohio Core** science graduation requirements of **Ohio Revised Code Section 3313.603**. This section of Ohio law requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

Physical geology incorporates chemistry, physics and environmental science and introduces students to key concepts, principles and theories within geology. Investigations are used to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

### SCIENCE INQUIRY AND APPLICATION

During the years of grades 9 through 12, all students must use the following scientific processes with appropriate **laboratory safety techniques** to construct their knowledge and understanding in all science content areas:

- Identify questions and concepts that guide scientific investigations;
- Design and conduct **scientific investigations**;
- Use technology and mathematics to improve investigations and communications;
- Formulate and revise explanations and models using logic and evidence (critical thinking);
- Recognize and analyze explanations and models; and Communicate and support a scientific argument.

## COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

### MINERALS

- Atoms and elements
- Chemical bonding (ionic, covalent, metallic)
- Crystallinity (crystal structure)
- Criteria of a mineral (crystalline solid, occurs in nature, inorganic, defined chemical composition)
- Properties of minerals (hardness, luster, cleavage, streak, crystal shape. fluorescence, flammability, density/specific gravity, malleability)

### IGNEOUS, METAMORPHIC AND SEDIMENTARY ROCKS

- Igneous
  - Mafic and felsic rocks and minerals
  - Intrusive (igneous structures: dikes, sills, batholiths, pegmatites)
  - Earth's interior (inner core, outer core, lower mantle, upper mantle, Mohorovicic discontinuity, crust)
  - Magnetic reversals and Earth's magnetic field
  - Thermal energy within the Earth
  - Extrusive (volcanic activity, volcanoes: cinder cones, composite, shield)
  - Bowen's Reaction Series (continuous and discontinuous branches)
- Metamorphic
  - Pressure, stress, temperature and compressional forces
  - Foliated (regional), non-foliated (contact)
  - Parent rock and degrees of metamorphism
  - Metamorphic zones (where metamorphic rocks are found)
- Sedimentary
  - The ocean
    - Tides (daily, neap and spring)
    - Currents (deep and shallow, rip and longshore)
    - Thermal energy and water density
    - Waves
    - Ocean features (ridges, trenches, island systems, abyssal zone, shelves, slopes, reefs, island arcs)
    - Passive and active continental margins
  - Division of sedimentary rocks and minerals (chemical, clastic/physical, organic)
  - Depositional environments
  - Streams (channels, streambeds, floodplains, cross-bedding, alluvial fans, deltas)
  - Transgressing and regressing sea levels

BACK TO INDEX

## EARTH'S HISTORY

- The geologic rock record
  - Relative and absolute age
  - Principles to determine relative age
    - Original horizontality
    - Superposition
    - Cross-cutting relationships
  - Absolute age
    - Radiometric dating (isotopes, radioactive decay)
    - Correct uses of radiometric dating
  - Combining relative and absolute age data
  - The geologic time scale
    - Comprehending geologic time
    - Climate changes evident through the rock record
    - Fossil record

## PLATE TECTONICS

- Internal Earth
  - Seismic waves
    - S and P waves
    - Velocities, reflection, refraction of waves
  - Structure of Earth **(Note: specific layers were part of grade 8)**
    - Asthenosphere
    - Lithosphere
    - Mohorovicic boundary (Moho)
    - Composition of each of the layers of Earth
    - Gravity, magnetism and isostasy
    - Thermal energy (geothermal gradient and heat flow)
- Historical review **(Note: this would include a review of continental drift and sea-floor spreading found in grade 8)**
  - Paleomagnetism and magnetic anomalies
  - Paleoclimatology
- Plate motion **(Note: introduced in grade 8)**
  - Causes and evidence of plate motion
  - Measuring plate motion
  - Characteristics of oceanic and continental plates
  - Relationship of plate movement and geologic events and features
  - Mantle plumes

## EARTH'S RESOURCES

- Energy resources
  - Renewable and nonrenewable energy sources and efficiency
  - Alternate energy sources and efficiency o Resource availability
  - Mining and resource extraction
- Air
  - Primary and secondary contaminants o Greenhouse gases
- Water
  - Potable water and water quality
  - Hypoxia, eutrophication
- Soil and sediment
  - Desertification
  - Mass wasting and erosion
  - Sediment contamination

## GLACIAL GEOLOGY

- Glaciers and glaciation
  - Evidence of past glaciers (including features formed through erosion or deposition)
  - Glacial deposition and erosion (including features formed through erosion or deposition)
  - Data from ice cores
    - Historical changes (glacial ages, amounts, locations, particulate matter, correlation to fossil evidence)
    - Evidence of climate changes throughout Earth's history
  - Glacial distribution and causes of glaciation
  - Types of glaciers – continental (ice sheets, ice caps), alpine/valley (piedmont, valley, cirque, ice caps)
  - Glacial structure, formation and movement

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

## CONTENT ELABORATION: MINERALS

This unit builds upon the middle school Earth and Space Science strand (beginning in grade 6), where common minerals are tested, minerals are defined and minerals are classified. In addition, the chemistry sections of the physical science syllabus support both mineral properties and crystalline structures (chemical compositions and bonding).

The emphasis at the high school level is to relate the chemical and physical components of minerals to the properties of the minerals. This requires extensive mineral testing, investigations, experimentation, observation, use of technology and models/modeling. The focus must be learning the ways to research, test and evaluate minerals, not in memorization of mineral names or types.

Properties such as cleavage and hardness must be connected to the chemical structure and bonding of the mineral. In addition, the environment in which minerals form should be part of the classification of the mineral, using mineral data to help interpret the environmental conditions that existed during the formation of the mineral.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Use crystal or atomic models to illustrate the crystal structure of common minerals. Relate the structure of the model to a specific quantifiable property (e.g., cleavage or hardness). Demonstrate and explain results to the class.
- Demonstrate (through specific testing, data collection, analysis and research) the relationship between mineral use, chemical formula, chemical bonds and the properties of the mineral. Document findings in writing.
- Research a specific mineral. Research questions should include: ***Where can the mineral be found (globally)? What environmental conditions must exist? How long does it take to form crystals? How is the mineral extracted? What is the mineral used for? What hazards, precautions, safety issues pertaining to the mineral or the extraction of the mineral exist? What is the economic value of the mineral? Are there any laws that may pertain to the mineral or the extraction of the mineral?*** Document the data in a scientific research paper or a poster session.
- Design and conduct an experiment to test specific properties of a mineral that has a unique use (e.g., a quartz battery or gypsum wallboard). Document process and findings in a scientific lab report.

### INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- Geology.com provides information on current events in all topic areas of geology, including resources and uses of resources, including minerals, at **http://geology.com/**.
- The U.S. Geological Survey provides mineral resources and information that can support the teaching of minerals at the high school and college level at **http://minerals.usgs.gov/minerals/**.
- The Mineralogical Society of America offers training, workshops, data and resources to support learning about minerals and geology. Find out more at **http://www.minsocam.org/**.
- The Digital Library for Earth Systems Education offers resources from a number of sources, such as *National Geographic*, government agencies and other scientific agencies. Grade 9-12 resources are provided at **http://www.dlese.org/library/query.do?q=&s=0&gr=02**.
- The College Board provides a document with 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 the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.

### COMMON MISCONCEPTIONS

- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.
- NASA provides common misconceptions for all ages about the Earth and geology at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

## CONTENT ELABORATION: IGNEOUS, METAMORPHIC AND SEDIMENTARY ROCKS

This unit builds upon the middle school Earth and Space Science strand (beginning in grade 6). Sedimentary, igneous and metamorphic rocks are introduced, rocks and minerals are tested and classified, plate tectonics, seismic waves and the structure of Earth are studied, and the geologic record is found (including the evidence of climatic variances through Earth's history). In the middle school Life Science strand, fossils and depositional environments are included as they relate to the documented history of life in the geologic record. In the physical science syllabus, support for waves, thermal energy, currents, pressure and gravity are presented.

At the high school level, geologic, topographic, seismic and aerial maps must be used to locate and recognize igneous, metamorphic and sedimentary structures and features. Technological advances permit the investigation of intrusive structures and the interior of Earth. Connections between the minerals present within each type of rock and the environment formed are important. The processes and environmental conditions that lead to fossil fuel formation (**Note: this links to the energy resources section below**) must include the fossil fuels found in Ohio, nationally and globally.

Bowen's Reaction Series must be used to develop an understanding of the relationship of cooling temperature, formation of specific igneous minerals and the resulting igneous environment. The focus is on knowing how to use Bowen's Reaction Series, not to memorize it. Virtual demonstrations and simulations of cooling magma and crystallization of the igneous minerals found on the series can be helpful in conceptualizing the chart.

The magnetic properties of Earth must be examined through the study of real data and evidence. The relationship of polar changes, magnetic stripping, grid north, true north and the north pole must be included in the study of Earth's magnetic properties.

While the ocean is included within the sedimentary topic, it can be incorporated into other topics. Features found in the ocean must include all types of environments (igneous, metamorphic or sedimentary). Using models (3-D or virtual) with real-time data to simulate waves, tides, currents, feature formation and changing sea levels to explore and investigate the ocean fully is recommended. Interpreting sections of the geologic record to determine sea level changes and depositional environments, including relative age is also recommended.

Technological advances must be used to illustrate the physical features of the Earth, including the ocean floor. Interpreting geologic history using maps of local cross-sections of bedrock can be related to the geologic history of Ohio, the United States and the Earth.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Use a geologic cross-section (or conduct a field investigation) for a specific location to analyze/interpret geologic history (rock type, formation, fossils or minerals present) and environmental conditions (including volcanic activity and/or transgressing and regressing sea levels). Share findings (can be a model, presentation or graphic) with the class.
- Identify specific geologic features using LANDSAT or other remote sensing data. Identify the factors required to create the specific features. Document findings graphically and in writing in a scientific journal, portfolio or e-portfolio.
- Create a map, model or lab investigation to illustrate a specific ocean current using real-time data. Relate the oceanic current to the Coriolis effect, density changes and physical features that exist. Present or demonstrate the product to the class. Defend and explain process and result.
- Design an investigation or experiment to demonstrate the magnetic reversals and the resulting magnetic striping that occurs at oceanic ridges. Document the process and result in writing, discuss or present to the class.
- Create a topographic, soil or geologic map of the school or community using actual data collected from the field (can use GPS/GIS readings, field studies/investigation, aerial maps or other available data to generate the map). Present final map in a poster session, with data used in the development of the map and the analysis of the data.
- Design and conduct a field study in a local area to locate fossil evidence that can help interpret the geologic history of the area (when combined with other rock evidence). Document the fieldwork and steps of the investigation in a scientific journal. Share the analysis of the data and the interpretation of the geologic history with the class through a presentation, portfolio, e- portfolio or poster session.

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The Digital Library for Earth Systems Education offers resources from a number of sources, such as *National Geographic*, government agencies and other scientific agencies. Grade 9-12 resources are provided at **http://www.dlese.org/library/query.do?q=&s=0&gr=02**.
- The Ohio Department of Natural Resources' Project Wet offers training and resources for K-12 teachers that promote deep understanding about all aspects of water and the interconnectedness of all of Earth's spheres (Earth Systems). Training and workshop opportunities can be found at **http://www.dnr.state.oh.us/tabid/3501/Default.aspx**.
- The College Board provides a document with 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 the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.

## COMMON MISCONCEPTIONS

- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.
- NASA provides common misconceptions for all ages about the Earth and geology at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

## CONTENT ELABORATION: EARTH'S HISTORY

This unit builds upon the middle school Earth and Space Science strand (beginning in grade 6), sedimentary, igneous and metamorphic rocks are introduced, rocks and minerals are tested and classified, plate tectonics, seismic waves and the structure of Earth are studied, and the geologic record is found (including uniformitarianism, superposition, cross-cutting relationships and the evidence of climatic variances through Earth's history). In the middle school Life Science strand, fossils and depositional environments are included as they relate to the documented history of life in the geologic record. In the physical science syllabus support for radiometric dating, seismic waves, thermal energy, pressure and gravity are presented.

At the high school level, the long-term history of Earth and the analysis of the evidence from the geologic record (including fossil evidence) must be investigated. Using actual sections of the geologic record to interpret, compare and analyze can demonstrate the changes that have occurred in Ohio, in North America and globally.

The emphasis for this unit is to explore the geologic record and the immensity of the geologic record. The analysis of data and evidence found in the variety of dating techniques (both absolute and relative), the complexity of the fossil record, and the impact that improving technology has had on the interpretation and continued updating of what is known about the history of Earth must be investigated. Geologic principles are essential in developing this level of knowledge. These principles must be tested and experienced through modeling, virtually, field studies, research and in-depth investigation.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Research a specific geologic time period. Document, using specific evidence and data, the environmental conditions, climate organisms that existed (through fossil evidence), orogenies, continental placement, etc. Present findings orally or in writing.
- Investigate the geologic history beneath the school or community using field data, geologic research (published by scientists or through a government agency) and/or bedrock geology maps and reports. Represent findings in a scientific research paper that includes graphics and data analysis or a 3-D model (can be virtual).
- Create a chart or table (can be virtual) to document the pattern of climate change that has occurred throughout geologic time using evidence from the rock record. Use published scientific data (that can be verified and validated) to document periods of climate fluctuation. Evaluate patterns and cause and effect that may be evident in the research. Share the graphic with the class. Discuss and defend the analysis and interpretation.
- Calculate, given the half-life and relative amounts of original isotope and daughter product in a rock sample, the estimated age of the sample (College Board Standards, 2010).

### INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The University of Maine offers a scientific case study of a specific glacier, including quantifiable data that documents measurable changes each year, at **http://climatechange.umaine.edu/Research/projects/byrdglacier.html**.
- The OSU Byrd Polar Research site offers numerous educational resources that are related to glacial geology and climate change at **http://bprc.osu.edu/**.
- The College Board provides a document with 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 the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.

### COMMON MISCONCEPTIONS

- Students may have misinformation and misconceptions that pertain to climate change. To address this, it is important to provide evidence of climate change throughout Earth's history and current data to document temperature changes (surface and oceanic). Data and other resources to help with teaching climate change can be found at **http://www.epa.gov/climatechange/index.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.
- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

- There are numerous misconceptions regarding Earth's history. Providing scientific data and research for students is essential in addressing them. Carleton College offers a number of strategies and resources that can be used to address Earth history misconceptions at **http://serc.carleton.edu/introgeo/earthhistory/geotime.html**.
- NASA provides common misconceptions for all ages about the Earth and geology at **http://www-istp.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

## CONTENT ELABORATION: PLATE TECTONICS

This unit builds upon the middle school Earth and Space Science strand (beginning in grade 6). Sedimentary, igneous and metamorphic rocks are introduced, rocks and minerals are tested and classified, plate tectonics (including the history and evidence for plate tectonics), seismic waves and the interior structure of Earth and the geologic record are found. In the middle school Life Science strand, fossils and depositional environments are included. In the physical science syllabus, support for density, convection, conductivity, motion, kinetic energy, radiometric dating, seismic waves, thermal energy, pressure and gravity are presented.

At the high school level, Earth's interior and plate tectonics must be investigated at greater depth using models, simulations, actual seismic data, real-time data, satellite data and remote sensing. Relationships between energy, tectonic activity levels and earthquake or volcano predictions, and calculations to obtain the magnitude, focus and epicenter of an earthquake must be included. Evidence and data analysis is the key in understanding this part of the Earth system. For example, GIS/GPS and/or satellite data provide data and evidence for moving plates and changing landscapes (due to tectonic activity).

The causes for plate motion, the evidence of moving plates and the results of plate tectonics must be related to Earth's past, present and future. The use of evidence to support conclusions and predictions pertaining to plate motion is an important part of this unit.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Research and investigate a specific area of ongoing plate movement. Create a presentation (can be virtual) that uses graphics and/or a 3-D model to document the evidence of movement, rate of movement, prediction for future movement and hazards that may exist due to movement. Collect and analyze authentic scientific data for each part of the research/investigation. Data and data analysis must be included in the documentation.
- Investigate contemporary methods of evaluating risk from plate movement (including earthquake and volcanic eruptions). Analyze earthquake and volcano data to identify patterns that can lead to predictability. Document the research in a scientific journal, portfolio or e- portfolio.
- Collect real-time data to document tectonic activity in the United States. Highlight the areas of greatest activity and compare to Ohio activity. Determine ways to harness energy from these areas (research and document existing methods in these areas). Present or discuss findings to the class.
- Construct representations of Earth's systems where convection currents occur, identifying areas of uneven heating and movement of matter (College Board Standards, 2010). Use remote sensing or real-time data to determine these zones. Document findings in a scientific report or journal.

### INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The Digital Library for Earth Systems Education offers resources from a number of sources, such as *National Geographic*, government agencies and other scientific agencies. Grade 9-12 resources are provided at **http://www.dlese.org/library/query.do?q=&s=0&gr=02**.
- The College Board provides a document with 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 the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.

### COMMON MISCONCEPTIONS

- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

## DIVERSE LEARNERS

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

- EarthComm offers a program that uses many different strategies to reach students of all learning levels at **http://www.agiweb.org/earthcomm/**The teaching of environmental science through relating the classroom to the real world is essential for many learners.

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

## CONTENT ELABORATION: EARTH'S RESOURCES

This unit builds on the Earth and Space Science content from elementary school, when renewable/nonrenewable energy, soils, the atmosphere and water are introduced, to grades 6-8 when Earth' spheres, Earth's resources and energy resources are found and then to biology and physical science (in particular water, air, chemistry and energy topics) syllabi at the high school level.

At the high school science level, renewable and nonrenewable energy resources topics investigate the effectiveness and efficiency for differing types of energy resources at a local, state, national and global level. Feasibility, availability and environmental cost are included in the extraction, storage, use and disposal of both abiotic and biotic resources. Modeling (3-D or virtual), simulations and real-world data must be used to investigate energy resources and exploration. The emphasis must be on current, actual data, contemporary science and technological advances in the field of energy resources.

Relating Earth's resources (energy, air, water, soil) to a global scale and using technology to collect global resource data for comparative classroom study is recommended. In addition, it is important to connect industry and the scientific community to the classroom to increase the depth of understanding. Critical thinking and problem-solving skills are important in evaluating resource use and conservation.

Smaller scale investigations, such as a field study to monitor stream quality, construction mud issues, stormwater management, nonpoint source-contamination problems (e.g., road-salt runoff, agricultural runoff, parking lot runoff) or thermal water contamination can be useful in developing a deeper understanding of Earth's resources.

Earth Systems must be used to illustrate the interconnectedness of each of Earth's spheres (the hydrosphere, lithosphere, atmosphere and biosphere) and the relationship between each type of Earth's resources.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Design and build (virtual, blueprint or 3-D model) an ***Eco-House*** that uses green technology and allows the house to be ***off-grid***. Designate a specific location and research/evaluate the different options that would be efficient and effective for that area. Present the final product (with complete explanation and defense of choices/options) to the class.
- Design an experiment to determine the amount and size of particulate matter in the air at the school or community. Analyze the results using information from the Environmental Protection Agency and the Department of Health (e.g., lung diseases, including emphysema and asthma). Locate specific Ohio data for comparative analysis. Report class findings and recommendations orally or in written form to school administrators.
- Investigate local contamination issues. Research existing laws that apply, recommend ways to reduce or prevent contamination (based on scientific data and research), invite community speakers/professionals and collect samples (water, soil, air) to test. Document findings, determine a way to share findings with the community and present to an authentic audience.
- Research and collect specific data for a mass wasting or desertification event (can be present day or historical). Research questions should include: ***What factors led to the event? What was the result of the event (how was each of Earth's spheres impacted)? What data is present (analyze data and draw conclusions)? What laws are related to the event? How can this be prevented in the future?*** Record the results graphically or in a scientific report.

### INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- NOAA provides real-time data for many of its projects and research missions at **http://www.noaa.gov/sciencemissions/bpoilspill.html**.
- *Science News* and *Science Daily* offer information highlighting science in the news that can be used for class discussions. The information is updated weekly or bi-weekly and provides references and resource sites for more in-depth discussion. Visit **http://www.sciencenews.org/** and **http://www.sciencedaily.com/**

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

- Geology.com provides information on current events in all topic areas of geology, including resources and uses of resources, at **http://geology.com/**
- NSTA provides learning modules called "SciPacks" that are designed to increase teacher content knowledge through inquiry-based modules. Find a module addressing Earth's resources and humans at **http://learningcenter.nsta.org/products/scipacks.aspx**
- The Ohio Department of Natural Resources' Project Wet offers training and resources for K-12 teachers that promote deep understanding about all aspects of water and the interconnectedness of all of Earth's spheres (Earth Systems). Training and workshop opportunities can be found at **http://www.dnr.state.oh.us/tabid/3501/Default.aspx**.
- The College Board provides a document with 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 the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.
- Project Wet's *Healthy Water, Healthy People* water quality educators guide offers ideas and resources for teaching all aspects of water and water contamination issues. Ideas for field monitoring, research projects and student investigations as well as teacher training are available at **http://www.projectwet.org/water-resources-education/water-quality-education/**.

**Career Connection**

In designing and building an *Eco-House*, students will include Ohio-based businesses and companies in their presentation. They will identify companies who manufacture qualifying materials, design suitable structures, and construct buildings that meet the specifications. Students will conduct career interviews, workplace visits, and navigate company websites to collect data and information. The explanations for choosing each company will be included in their presentation.

## COMMON MISCONCEPTIONS

- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

## CONTENT ELABORATION: GLACIAL GEOLOGY

This unit builds upon the fourth-grade introduction of Earth's surface (landforms and features, including glacial geology) and the middle school Earth and Space Science strand, with sedimentary, igneous and metamorphic rocks, sediment and soils, the geologic record and Earth's history, the cryosphere and the relationship of the analysis of ice cores in understanding changes in climate over thousands of years. Fossils and fossil evidence within the geologic record is found in the Life Science strand, building from second grade through high school biology.

Tracing and tracking glacial history and present-day data for Ohio, the United States and globally is an emphasis for this unit. Scientific data found in the analysis of the geologic record, ice cores and surficial geology should be used to provide the evidence for changes that have occurred over the history of Earth and are observable in the present day. New discoveries, mapping projects, research, contemporary science and technological advances must be included in the study of glacial geology.

Modeling and simulations (3-D or virtual) can be used to illustrate glacial movement and the resulting features. The focus should be on the geologic processes and the criteria for movement, not on memorizing the names of types of glaciers.

Field investigations to map and document evidence of glaciers in the local area (if applicable) or virtual investigations can help demonstrate the resulting glacial features and the impact that ice has had on the surface of Earth throughout history. Real-time data (using remote sensing, satellite, GPS/GIS, aerial photographs/maps) can help support this topic.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Create a cross-section (virtual or drawn) or a 3-D model of a specific type of glacier and use the model or graphic to explain how the glacier moves to the class. Explain and defend data and evidence in the demonstration.
- Take a field trip to an area of Ohio that has visible glacial features. (Check the Ohio Department of Natural Resources, state parks and/or metro parks that have access to view glacial features throughout the state.) Compare the area to maps or satellite data or visit a scientific center that studies glaciers or glacial formation (e.g., the Byrd Polar Research Center) to see glacial core data and learn about glaciers from experts (what kind of data is collected and how it is analyzed). Document observations in a scientific journal or paper (including graphics where appropriate).
- Research the glacial history of a specific location using data from the rock record, contemporary field data (research conducted and published by scientists) and/or glacial features that can be documented (maps, virtual/aerial documentation, remote sensing data). Relate the history to contemporary evidence of changing climate. Present or discuss findings with the class.
- Design and conduct a field study in a local or a specific area within Ohio to collect and/or map evidence of glacial activity (e.g., collection of glacial erratics, photographic evidence of striations from glacial movement or glacial features). Using specific data, share and defend findings with the class.
- Using aerial photographs, LANDSAT data, surficial geology maps or topographic maps, recognize and identify different types of glaciers and glacier features. Document the types of glaciers graphically and in writing in a scientific journal, portfolio or e-portfolio.

BACK TO INDEX

BACK TO PHYSICAL GEOLOGY OUTLINE

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The OSU Byrd Polar Research site offers numerous educational resources that are related to glacial geology and climate change at **http://bprc.osu.edu/**
- The College Board provides a document with 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 the student. Find it at **http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf**.
- The Ohio Department of Natural Resources' Project Wet offers training and resources for K-12 teachers that promote deep understanding about all aspects of water and the interconnectedness of all of Earth's spheres (Earth Systems). Training and workshop opportunities can be found at **http://www.dnr.state.oh.us/tabid/3501/Default.aspx**.

## COMMON MISCONCEPTIONS

- Students may have misinformation and misconceptions that pertain to climate change. To address this, it is important to provide evidence of climate change throughout Earth's history and current data to document temperature changes (surface and oceanic). Data and other resources to help with teaching climate change can be found at **http://www.epa.gov/climatechange/index.html**.
- Carleton College lists a number of geologic misconceptions for high school and college-age students at **http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html**.
- Misconceptions regarding all aspects of environmental science must be addressed through scientific data analysis, investigation and research. Discussing the conclusions and findings through a professional "gallery walk" can be a very useful way to determine possible misconceptions that exist for the class and address them. Carleton College offers a gallery walk website at **http://serc.carleton.edu/introgeo/gallerywalk/misconceptions.html**.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

Annenberg offers ideas about teaching high school level environmental science using an integrated Earth systems approach at **http://www.learner.org/resources/series209.html**.

BACK TO INDEX

# Physics

## SYLLABUS AND MODEL CURRICULUM

### COURSE DESCRIPTION

Physics is a high school level course, which satisfies the **Ohio Core** science graduation requirements of **Ohio Revised Code Section 3313.603**. This section of Ohio law requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

Physics elaborates on the study of the key concepts of motion, forces and energy as they relate to increasingly complex systems and applications that will provide a foundation for further study in science and scientific literacy.

Students engage in investigations to understand and explain motion, forces and energy in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

### SCIENCE INQUIRY AND APPLICATION

During the years of grades 9 through 12, all students must use the following scientific processes with appropriate **laboratory safety techniques** to construct their knowledge and understanding in all science content areas:

- Identify questions and concepts that guide scientific investigations;
- Design and conduct **scientific investigations**;
- Use technology and mathematics to improve investigations and communications;
- Formulate and revise explanations and models using logic and evidence (critical thinking);
- Recognize and analyze explanations and models; and
- Communicate and support a scientific argument.

## COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

### MOTION

- Graph interpretations
  - Position vs. time
  - Velocity vs. time
  - Acceleration vs. time
- Problem solving
  - Using graphs (average velocity, instantaneous velocity, acceleration, displacement, change in velocity)
  - Uniform acceleration including free fall (initial velocity, final velocity, time, displacement, acceleration, average velocity)
- Projectiles
  - Independence of horizontal and vertical motion
  - Problem-solving involving horizontally launched projectiles

### FORCES, MOMENTUM AND MOTION

- Newton's laws applied to complex problems
- Gravitational force and fields
- Elastic forces
- Friction force (static and kinetic)
- Air resistance and drag
- Forces in two dimensions
  - Adding vector forces
  - Motion down inclines
  - Centripetal forces and circular motion
- Momentum, impulse and conservation of momentum

### ENERGY

- Gravitational potential energy
- Energy in springs
- Nuclear energy
- Work and power
- Conservation of energy

BACK TO INDEX

## WAVES

- Wave properties
  - Conservation of energy
  - Reflection
  - Refraction
  - Interference
  - Diffraction
- Light phenomena
  - Ray diagrams (propagation of light)
  - Law of reflection (equal angles)
  - Snell's law
  - Diffraction patterns
  - Wave – particle duality of light
  - Visible spectrum and color

## ELECTRICITY AND MAGNETISM

- Charging objects (friction, contact and induction)
- Coulomb's law
- Electric fields and electric potential energy
- DC circuits
  - Ohm's law
  - Series circuits
  - Parallel circuits
  - Mixed circuits
  - Applying conservation of charge and energy (junction and loop rules)
- Magnetic fields and energy
- Electromagnetic interactions

BACK TO INDEX

BACK TO PHYSICS OUTLINE

## CONTENT ELABORATION: MOTION

### Motion

In physical science, the concepts of position, displacement, velocity and acceleration were introduced and straight-line motion involving either uniform velocity or uniform acceleration was investigated and represented in position vs. time graphs, velocity vs. time graphs, motion diagrams and data tables.

In this course, acceleration vs. time graphs are introduced and more complex graphs are considered that have both positive and negative displacement values and involve motion that occurs in stages (e.g., an object accelerates then moves with constant velocity). Symbols representing acceleration are added to motion diagrams and mathematical analysis of motion becomes increasingly more complex. Motion must be explored through investigation and experimentation. Motion detectors and computer graphing applications can be used to collect and organize data. Computer simulations and video analysis can be used to analyze motion with greater precision.

- **Motion Graphs**
  Instantaneous velocity for an accelerating object can be determined by calculating the slope of the tangent line for some specific instant on a position vs. time graph. Instantaneous velocity will be the same as average velocity for conditions of constant velocity, but this is rarely the case for accelerating objects. The position vs. time graph for objects increasing in speed will become steeper as they progress and the position vs. time graph for objects decreasing in speed will become less steep.

  On a velocity vs. time graph, objects increasing in speed will slope away from the x-axis and objects decreasing in speed will slope toward the x-axis. The slope of a velocity vs. time graph indicates the acceleration so the graph will be a straight line (not necessarily horizontal) when the acceleration is constant. Acceleration is positive for objects speeding up in a positive direction or objects slowing down in a negative direction. Acceleration is negative for objects slowing down in a positive direction or speeding up in a negative direction. These are not concepts that should be memorized, but can be developed from analyzing the definition of acceleration and the conditions under which acceleration would have these signs. The word "deceleration" should not be used since it provides confusion between slowing down and negative acceleration. The area under the curve for a velocity vs. time graph gives the change in position (displacement) but the absolute position cannot be determined from a velocity vs. time graph.

  Objects moving with uniform acceleration will have a horizontal line on an acceleration vs. time graph. This line will be at the x-axis for objects that are either standing still or moving with constant velocity. The area under the curve of an acceleration vs. time graph gives the change in velocity for the object, but the displacement, position and the absolute velocity cannot be determined from an acceleration vs. time graph. The details about motion graphs should not be taught as rules to memorize, but rather as generalizations that can be developed from interpreting the graphs.
- **Problem Solving**
  Many problems can be solved from interpreting graphs and charts as detailed in the motion graphs section. In addition, when acceleration is constant, average velocity can be calculated by taking the average of the initial and final instantaneous velocities ($□□_{avg} = (v_f - v_i)/2$). This relationship does not hold true when the acceleration changes. The equation can be used in conjunction with other kinematics equations to solve increasingly complex problems, including those involving free fall with negligible air resistance in which objects fall with uniform acceleration. Near the surface of Earth, in the absence of other forces, the acceleration of freely falling objects is 9.81 $m/s^2$. Assessments of motion problems, including projectile motion, will not include problems that require the quadratic equation to solve.
- **Projectile Motion**
  When an object has both horizontal and vertical components of motion, as in a projectile, the components act independently of each other. For a projectile in the absence of air resistance, this means that horizontally, the projectile will continue to travel at constant speed just like it would if there were no vertical motion. Likewise, vertically the object will accelerate just as it would without any horizontal motion. Problem solving will be limited to solving for the range, time, initial height, initial velocity or final velocity of horizontally launched projectiles with negligible air resistance.

  While it is not inappropriate to explore more complex projectile problems, it must not be done at the expense of other parts of the curriculum.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO PHYSICS OUTLINE

## VISIONS INTO PRACTICE

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

- A buggy moving at constant velocity is released from the top of a ramp 1.0 second before a cart that starts from rest and accelerates down the ramp. At what position on the ramp will the buggy and the cart collide? All data, graphs, calculations and explanations must be clearly represented and annotated to explain how the answer was determined. The cart and the buggy may be checked out one at a time to collect data, but may not be used together until the prediction is ready to be tested.
- Investigate the motion of a freely falling body using either a ticker timer or a motion detector. Use mathematical analysis to determine a value for "***g***." Compare the experimental value to known values of "***g***." Suggest sources of error and possible improvements to the experiment.

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- "**Moving man**" is an interactive simulation from PhET that allows students to set position, velocity and acceleration, watch the motion of the man and see the position vs. time, velocity vs. time and acceleration vs. time graphs.
- "**Motion in 2-D**" is an interactive simulation from PhET that shows the magnitude and direction of the velocity and accelerations for different types of motion.
- "**Motion Diagrams**" is a tutorial from Western Kentucky University that shows how to draw motion diagrams for a variety of motions. It includes an animated physlet.
- "**Projectile Motion**" is a physlet from High Point University that illustrates the independence of horizontal and vertical motion in projectile motion. The projectile motion is shown in slow motion so the horizontal and vertical positions of the ball can be clearly tracked and analyzed. While it shows a projectile launched at an angle, it emphasizes the conceptual aspects of projectile motion that are appropriate for physics students.
- **Modeling workshops** are available nationally that help teachers develop a framework for incorporating guided inquiry in their instruction.

## COMMON MISCONCEPTIONS

Students often think that:

- **Two objects** side by side must have the same speed.
- Acceleration and velocity are always in the same direction.
- Velocity is a force.
- If velocity is zero, then acceleration must be zero, too.
- Heavier objects fall faster than light ones.
- Acceleration is the same as velocity.
- The acceleration of a falling object depends upon its mass.
- Freely falling bodies can only move downward.
- There is no gravity in a vacuum.
- Gravity only acts on things when they are falling.
- **When the velocity is constant**, so is the acceleration.

Students do not realize that the acceleration is zero. If the speed is constant, there is no acceleration. A positive acceleration is always associated with speeding up and a negative acceleration is always associated with slowing down.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

"**Teaching High School Science**" is a series of videos-on-demand produced by Annenberg that show classroom strategies for implementing inquiry into the high school classroom. While not all of the content is aligned to physical science, the strategies can be applied to any content.

BACK TO INDEX

BACK TO PHYSICS OUTLINE

## CONTENT ELABORATION: FORCES, MOMENTUM AND MOTION

### Forces, Momentum and Motion

In earlier grades, Newton's laws of motion were introduced; gravitational forces and fields were described conceptually; the gravitational force (weight) acting on objects near Earth's surface was calculated; friction forces and drag were addressed conceptually and quantified from force diagrams; and forces required for circular motion were introduced conceptually. In this course, Newton's laws of motion are applied to mathematically describe and predict the effects of forces on more complex systems of objects and to analyze objects in free fall that experience significant air resistance.

Gravitational forces are studied as a universal phenomenon and gravitational field strength is quantified. Elastic forces and a more detailed look at friction are included. At the atomic level, "contact" forces are actually due to the forces between the charged particles of the objects that appear to be touching. These electric forces are responsible for friction forces, normal forces and other "contact" forces. Air resistance and drag are explained using the particle nature of matter. Projectile motion is introduced and circular motion is quantified. The vector properties of momentum and impulse are introduced and used to analyze elastic and inelastic collisions between objects. Analysis of experimental data collected in laboratory investigations must be used to study forces and momentum. This can include the use of force probes and computer software to collect and analyze data.

- **Newton's laws**
  Newton's laws of motion, especially the third law, can be used to solve complex problems that involve systems of many objects that move together as one (e.g., an Atwood's machine). The equation $a = F_{net}/m$ that was introduced in physical science can be used to solve more complex problems involving systems of objects and situations involving forces that must themselves be quantified (e.g., gravitational forces, elastic forces, friction forces).
- **Gravitational Forces and Fields**
  Gravitational interactions are very weak compared to other interactions and are difficult to observe unless one of the objects is extremely massive (e.g., the sun, planets, moons). The force law for gravitational interaction states that the strength of the gravitational force is proportional to the product of the two masses and inversely proportional to the square of the distance between the centers of the masses, $F_g = (G \cdot m_1 \cdot m_2)/r^2$). The proportionality constant, $G$, is called the universal gravitational constant. Problem solving may involve calculating the net force for an object between two massive objects (e.g., Earth-moon system, planet-sun system) or calculating the position of such an object given the net force.

  The strength of an object's (i.e., the source's) gravitational field at a certain location, $g$, is given by the gravitational force per unit of mass experienced by another object placed at that location, $g = F_g / m$. Comparing this equation to Newton's second law can be used to explain why all objects on Earth's surface accelerate at the same rate in the absence of air resistance. While the gravitational force from another object can be used to determine the field strength at a particular location, the field of the object is always there, even if the object is not interacting with anything else. The field direction is toward the center of the source. Given the gravitational field strength at a certain location, the gravitational force between the source of that field and any object at that location can be calculated. Greater gravitational field strengths result in larger gravitational forces on masses placed in the field. Gravitational fields can be represented by field diagrams obtained by plotting field arrows at a series of locations. Field line diagrams are excluded from this course. Distinctions between gravitational and inertial masses are excluded.

  A scale indicates weight by measuring the normal force between the object and the surface supporting it. The reading on the scale accurately measures the weight if the system is not accelerating and the net force is zero. However, if the scale is used in an accelerating system as in an elevator, the reading on the scale does not equal the actual weight. The scale reading can be referred to as the "apparent weight." This apparent weight in accelerating elevators can be explained and calculated using force diagrams and Newton's laws.
- **Elastic Forces**
  Elastic materials stretch or compress in proportion to the load they support. The mathematical model for the force that a linearly elastic object exerts on another object is $F_{elastic} = k\Delta x$, where $\Delta x$ is the displacement of the object from its relaxed position. The direction of the elastic force is always toward the relaxed position of the elastic object. The constant of proportionality, $k$, is the same for compression and extension and depends on the "stiffness" of the elastic object.
- **Friction Forces**
  The amount of kinetic friction between two objects depends on the electric forces between the atoms of the two surfaces sliding past each other. It also depends upon the magnitude of the normal force that pushes the two surfaces together. This can be represented mathematically as $F_k = \mu_k F_N$, where $\mu_k$ is the coefficient of kinetic friction that depends upon the materials of which the two surfaces are made.

  Sometimes friction forces can prevent objects from sliding past each other, even when an external force is applied parallel to the two surfaces that are in contact. This is called static friction, which is mathematically represented by $F_s \leq \mu_s F_N$. The maximum amount of static friction possible depends on the types of materials that make up the two surfaces and the magnitude of the normal force pushing the objects together, $F_{smax} = \mu_s F_N$. As long as the external net force is less than or equal to the maximum force of static friction, the objects will not move relative to one another. In this case, the actual static friction force acting on the object will be equal to the net external force acting on the object, but in the opposite direction. If the external net force exceeds the maximum static friction force for the object,

BACK TO INDEX

BACK TO PHYSICS OUTLINE

the objects will move relative to each other and the friction between them will no longer be static friction, but will be kinetic friction.

- **Air Resistance and Drag**
  Liquids have more drag than gases like air. When an object pushes on the particles in a fluid, the fluid particles can push back on the object according to Newton's third law and cause a change in motion of the object. This is how helicopters experience lift and how swimmers propel themselves forward. Forces from fluids will only be quantified using Newton's second law and force diagrams.
- **Forces in Two Dimensions**
  Net forces will be calculated for force vectors with directions between 0° and 360° or a certain angle from a reference (e.g., 37° above the horizontal). Vector addition can be done with trigonometry or by drawing scaled diagrams. Problems can be solved for objects sliding down inclines. The net force, final velocity, time, displacement and acceleration can be calculated. Inclines will either be frictionless or the force of friction will already be quantified. Calculations of friction forces down inclines from the coefficient of friction and the normal force will not be addressed in this course.

  An object moves at constant speed in a circular path when there is a constant net force that is always directed at right angles to the direction in motion toward the center of the circle. In this case, the net force causes an acceleration that shows up as a change in direction. If the force is removed, the object will continue in a straight-line path. The nearly circular orbits of planets and satellites result from the force of gravity. Centripetal acceleration is directed toward the center of the circle and can be calculated by the equation $a_c = v^2/r$, where $v$ is the speed of the object and $r$ is the radius of the circle. This expression for acceleration can be substituted into Newton's second law to calculate the centripetal force. Since the centripetal force is a net force, it can be equated to friction (unbanked curves), gravity, elastic force, etc., to perform more complex calculations.
- **Momentum, Impulse and Conservation of Momentum**
  Momentum, $p$, is a vector quantity that is directly proportional to the mass, $m$, and the velocity, $v$, of the object. Momentum is in the same direction the object is moving and can be mathematically represented by the equation $p = mv$. The conservation of linear momentum states that the total (net) momentum before an interaction in a closed system is equal to the total momentum after the interaction. In a closed system, linear momentum is always conserved for elastic, inelastic and totally inelastic collisions. While total energy is conserved for any collision, in an elastic collision, the kinetic energy also is conserved. Given the initial motions of two objects, qualitative predictions about the change in motion of the objects due to a collision can be made. Problems can be solved for the initial or final velocities of objects involved in inelastic and totally inelastic collisions. For assessment purposes, momentum may be dealt with in two dimensions conceptually, but calculations will only be done in one dimension. Coefficients of restitution are beyond the scope of this course.

  Impulse, $\Delta p$, is the total momentum transfer into or out of a system. Any momentum transfer is the result of interactions with objects outside the system and is directly proportional to both the average net external force acting on the system, $F_{avg}$, and the time interval of the interaction, $\lambda t$. It can mathematically be represented by $\Delta p = p_f - p_i = F_{avg}\,\Delta t$. This equation can be used to justify why momentum changes due to the external force of friction can be ignored when the time of interaction is extremely short. Average force, initial or final velocity, mass or time interval can be calculated in multi-step word problems. For objects that experience a given impulse (e.g., a truck coming to a stop), a variety of force/time combinations are possible. The time could be small, which would require a large force (e.g., the truck crashing into a brick wall to a sudden stop). Conversely, the time could be extended which would result in a much smaller force (e.g., the truck applying the breaks for a long period of time).

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE

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

- Given two spring-loaded dynamic carts with different masses that are located on a table between two wooden blocks, determine where the carts must be placed so that they hit the blocks simultaneously. Measurements may be taken of the model set up at the front of the room, but the carts may not be released prior to determination. Clearly justify the answer and state any assumptions that were made. Test your prediction with the model set up at the front of the room.
- Plan and conduct a scientific investigation to determine the relationship between the force exerted on a spring and the amount it stretches. Represent the data graphically. Analyze the data to determine patterns and trends and model the relationship with a mathematical equation. Describe the relationship in words and support the conclusion with experimental evidence.

BACK TO INDEX

BACK TO PHYSICS OUTLINE

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- "**Collision Lab**" is an interactive simulation that allows students to Investigate collisions on an air hockey table. Students can vary the number of discs, masses, elasticity and initial conditions to see if momentum and kinetic energy are conserved.
- "**Forces and Motion**" is an interactive simulation that allows students to explore the forces present when a filing cabinet is pushed. Students can create an applied force and see the resulting friction force and total force acting on the cabinet. Graphs show forces vs. time, position vs. time, velocity vs. time, and acceleration vs. time. A force diagram of all the forces (including gravitational and normal forces) is shown.

## COMMON MISCONCEPTIONS

Students often think that:

- **Forces are required** for motion with constant velocity.
- Inertia deals with the state of motion (at rest or in motion).
- All objects can be moved with equal ease in the absence of gravity.
- All objects eventually stop moving when the force is removed.
- Inertia is the force that keeps objects in motion.
- If two objects are both at rest, they have the same amount of inertia.
- Velocity is absolute and not dependent on the frame of reference.
- Action-reaction forces act on the same body.
- There is no connection between Newton's laws and kinematics.
- The product of mass and acceleration, ma, is a force.
- Friction cannot act in the direction of motion.
- The normal force on an object is equal to the weight of the object by the third law.
- The normal force on an object always equals the weight of the object.
- Equilibrium means that all the forces on an object are equal.
- Equilibrium is a consequence of the third law.
- Only animate things (people, animals) exert forces; passive ones (tables, floors) do not exert forces.
- Once an object is moving, heavier objects push more than lighter ones.
- Newton's third law can be overcome by motion (e.g., by a jerking motion).
- A force applied by an object, like a hand, still acts on an object after the object leaves the hand.
- The moon is not falling.
- The moon is not in free fall. The force that acts on an apple is not the same as the force that acts on the moon.
- The gravitational force is the same on all falling bodies.
- There are no gravitational forces in space.
- The gravitational force acting on the Space Shuttle is nearly zero.
- The gravitational force acts on one mass at a time.
- The moon stays in orbit because the gravitational force on it is balanced by the centrifugal force acting on it.
- Weightlessness means there is no gravity.
- The Earth's spinning motion causes gravity.
- Momentum is not a vector.
- Conservation of momentum applies only to collisions.
- Momentum is the same as force.
- Moving masses in the absence of gravity do not have momentum.
- Momentum is not conserved in collisions with "immovable" objects.
- Momentum and kinetic energy are the same.
- Circular motion does not require a force.
- Centrifugal forces are real.
- An object moving in circle with constant speed has no acceleration.
- An object moving in a circle will continue in circular motion when released.
- An object in circular motion will fly out radially when released.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

"**Teaching High School Science**" is a series of videos-on-demand produced by Annenberg that show classroom strategies for implementing inquiry into the high school classroom. While not all of the content is aligned to physical science, the strategies can be applied to any content.

BACK TO INDEX

BACK TO PHYSICS OUTLINE

## CONTENT ELABORATION: ENERGY

### Energy

In physical science, the role of strong nuclear forces in radioactive decay, half-lives, fission and fusion, and mathematical problem solving involving kinetic energy, gravitational potential energy, energy conservation and work (when the force and displacement were in the same direction) were introduced. In this course, the concept of gravitational potential energy is understood from the perspective of a field, elastic potential energy is introduced and quantified, nuclear processes are explored further, the concept of mass-energy equivalence is introduced, the concept of work is expanded, power is introduced, and the principle of conservation of energy is applied to increasingly complex situations. Energy must be explored by analyzing data gathered in scientific investigations. Computers and probes can be used to collect and analyze data.

- **Gravitational Potential Energy**
  When two attracting masses interact, the kinetic energies of both objects change but neither is acting as the energy source or the receiver. Instead, the energy is transferred into or out of the gravitational field around the system as gravitational potential energy. A single mass does not have gravitational potential energy. Only the system of attracting masses can have gravitational potential energy. When two masses are moved farther apart, energy is transferred into the field as gravitational potential energy. When two masses are moved closer together, gravitational potential energy is transferred out of the field.
- **Energy in Springs**
  The approximation for the change in the potential elastic energy of an elastic object (e.g., a spring) is $\Delta E_{elastic} = \frac{1}{2} k \Delta x^2$ where $\Delta x$ is the distance the elastic object is stretched or compressed from its relaxed length.
- **Nuclear Energy**
  Alpha, beta, gamma and positron emission each have different properties and result in different changes to the nucleus. The identity of new elements can be predicted for radioisotopes that undergo alpha or beta decay. During nuclear interactions, the transfer of energy out of a system is directly proportional to the change in mass of the system as expressed by $E = mc^2$, which is known as the equation for mass-energy equivalence. A very small loss in mass is accompanied by a release of a large amount of energy. In nuclear processes such as nuclear decay, fission and fusion, the mass of the product is less than the mass of the original nuclei. The missing mass appears as energy. This energy can be calculated for fission and fusion when given the masses of the particle(s) formed and the masses of the particle(s) that interacted to produce them.
- **Work and Power**
  Work can be calculated for situations in which the force and the displacement are at angles to one another using the equation $W = F\Delta x(\cos\theta)$ where $W$ is the work, $F$ is the force, $\Delta x$ is the displacement, and $\theta$ is the angle between the force and the displacement. This means when the force and the displacement are at right angles, no work is done and no energy is transferred between the objects. Such is the case for circular motion.

  The rate of energy change or transfer is called power (P) and can be mathematically represented by $P = \Delta E / \Delta t$ or $P = W / \Delta t$. Power is a scalar property. The unit of power is the watt ($W$), which is equivalent to one Joule of energy transferred in one second ($J/s$).
- **Conservation of Energy**
  The total initial energy of the system and the energy entering the system are equal to the total final energy of the system and the energy leaving the system. Although the various forms of energy appear very different, each can be measured in a way that makes it possible to keep track of how much of one form is converted into another. Situations involving energy transformations can be represented with verbal or written descriptions, energy diagrams and mathematical equations. Translations can be made between these representations.

  The conservation of energy principle applies to any defined system and time interval within a situation or event in which there are no nuclear changes that involve mass-energy equivalency. The system and time interval may be defined to focus on one particular aspect of the event. The defined system and time interval may then be changed to obtain information about different aspects of the same event.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

### VISIONS INTO PRACTICE

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

- Design and build a mousetrap car that will travel across the floor. Test and calibrate the vehicle so that the distance it travels can be controlled. After calibrating the cars, each group will be given a different target distance for each of the cars to reach. Designs will be compared and evaluated to determine the most effective design factors.
- Release a cart from several different positions on a ramp and let it travel to the bottom of the ramp and across the table until it slows to a stop. Investigate the relationship between the height of release and the distance it travels before stopping. From the data, determine the average friction force acting on the rolling cart. Identify the assumptions used to determine the friction force.

BACK TO INDEX

BACK TO PHYSICS OUTLINE

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- "**Masses and Springs**" is an interactive simulation from PhET that allows students to hang masses from springs and adjust the spring stiffness and damping, and transport the apparatus to different planets. The resulting motion can be shown in slow motion. A chart shows the kinetic, potential and thermal energy for each spring.
- **This tutorial** from The Physics Classroom demonstrates the strategy of using energy bar graphs to solve conservation of energy problems.
- Constructing energy bar graphs is a way for students to conceptually organize the energy changes involved in a problem. Once such a diagram is completed, the appropriate equation for a specific problem can be written using an understanding of conservation of matter. **Some methods** show work done on and by the system as energy flowing into and out of the system. **Other methods** show work done on and by the system as a part of the bar graph. The second reference shows the equation first, then the diagram. However, students have an easier time drawing the diagram, then writing the equation from the diagram.
- Energy flow diagrams picture energy transformations in an accurate, quantitative and conceptually transparent manner. **Energy Flow Diagrams for Teaching Physics Concepts** is a paper that was published in *The Physics Teacher* that outlines how to use these tools in the classroom. It proceeds from simple processes to complex socially significant processes such as global warming.

## COMMON MISCONCEPTIONS

Students often think that:

- **Energy gets** used up or runs out.
- Something not moving cannot have any energy.
- Force acting on an object does work even if the object does not move.
- Energy is destroyed in transformations from one type to another.
- Energy can be recycled.
- Gravitational potential energy is the only type of potential energy.
- When an object is released to fall, the gravitational potential energy immediately becomes all kinetic energy.
- Energy is not related to Newton's laws.
- Energy is a force.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

"**Teaching High School Science**" is a series of videos-on-demand produced by Annenberg that show classroom strategies for implementing inquiry into the high school classroom. While not all of the content is aligned to physical science, the strategies can be applied to any content.

BACK TO INDEX

BACK TO PHYSICS OUTLINE

## CONTENT ELABORATION: WAVES

### Waves

In earlier grades, the electromagnetic spectrum and basic properties (wavelength, frequency, amplitude) and behaviors of waves (absorption, reflection, transmission, refraction, interference, diffraction) were introduced. In this course, conservation of energy is applied to waves and the measurable properties of waves (wavelength, frequency, amplitude) are used to mathematically describe the behavior of waves (index of refraction, law of reflection, single- and double-slit diffraction). The wavelet model of wave propagation and interactions is not addressed in this course. Waves must be explored experimentally in the laboratory. This may include, but is not limited to, water waves, waves in springs, the interaction of light with mirrors, lenses, barriers with one or two slits, and diffraction gratings.

- **Wave Properties**

  When a wave reaches a barrier or a new medium, a portion of its energy is reflected at the boundary and a portion of the energy passes into the new medium. Some of the energy that passes to the new medium may be absorbed by the medium and transformed to other forms of energy, usually thermal energy, and some continues as a wave in the new medium. Some of the energy also may be dissipated, no longer part of the wave since it has been transformed into thermal energy or transferred out of the system due to the interaction of the system with surrounding objects. Usually all of these processes occur simultaneously, but the total amount of energy must remain constant.

  When waves bounce off barriers (reflection), the angle at which a wave approaches the barrier (angle of incidence) equals the angle at which the wave reflects off the barrier (angle of reflection). When a wave travels from a two-dimensional (e.g., surface water, seismic waves) or three- dimensional (e.g., sound, electromagnetic waves) medium into another medium in which the wave travels at a different speed, both the speed and the wavelength of the transferred wave change. Depending on the angle between the wave and the boundary, the direction of the wave also can change resulting in refraction. The amount of bending of waves around barriers or small openings (diffraction) increases with decreasing wavelength. When the wavelength is smaller than the obstacle or opening, no noticeable diffraction occurs. Standing waves and interference patterns between two sources are included in this topic. As waves pass through a single or double slit, diffraction patterns are created with alternating lines of constructive and destructive interference. The diffraction patterns demonstrate predictable changes as the width of the slit(s), spacing between the slits and/or the wavelength of waves passing through the slits changes.
- **Light phenomena**

  The path of light waves can be represented with ray diagrams to show reflection and refraction through converging lenses, diverging lenses and plane mirrors. Since light is a wave, the law of reflection applies. Snell's law, $n_1 sin\theta_1 = n_2 sin\theta_2$, quantifies refraction in which $n$ is the index of refraction of the medium and $\lambda$ is the angle the wave enters or leaves the medium, when measured from the normal line. The index of refraction of a material can be calculated by the equation $n = c/v$, where $n$ is the index of refraction of a material, $v$ is the speed of light through the material, and $c$ is the speed of light in a vacuum. Diffraction patterns of light must be addressed, including patterns from diffraction gratings.

  There are two models of how radiant energy travels through space at the speed of light. One model is that the radiation travels in discrete packets of energy called photons that are continuously emitted from an object in all directions. The energy of these photons is directly proportional to the frequency of the electromagnetic radiation. This particle-like model is called the photon model of light energy transfer. A second model is that radiant energy travels like a wave that spreads out in all directions from a source. This wave-like model is called the electromagnetic wave model of light energy transfer. Strong scientific evidence supports both the particle-like model and wave-like model. Depending on the problem scientists are trying to solve, either the particle- like model or the wave-like model of radiant energy transfer is used. Students are not required to know the details of the evidence that supports either model at this level.

  Humans can only perceive a very narrow portion of the electromagnetic spectrum. Radiant energy from the sun or a light bulb filament is a mixture of all the colors of light (visible light spectrum). The different colors correspond to different radiant energies. When white light hits an object, the pigments in the object reflect one or more colors in all directions and absorb the other colors.

### EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

BACK TO INDEX

BACK TO PHYSICS OUTLINE

## VISIONS INTO PRACTICE

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

- Design a system involving three refraction tanks and three different lenses so that a beam of light entering the system at a given angle can pass through all three tanks of liquid and leave the other side at a different angle.
- Investigate the refraction of light as it passes from air into a new liquid medium. Draw incident and refracted rays for many different angles and measure the angles of both. Present the material graphically to determine the index of refraction for the liquid.

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- "**Radio waves and electromagnetic fields**" is an interactive simulation from PhET that allows students to explore how electromagnetic radiation is produced. Students can wiggle the transmitter electron manually or have it oscillate automatically and display the field as a curve or as vectors. There is a strip chart that shows the electron positions at the transmitter and at the receiver.
- "**Geometric Optics**" is an interactive simulation from PhET that illustrates how light rays are refracted by a lens. Students can adjust the focal length of the lens, move the object, move the lens or move the screen and see how the image changes.

### Career Connection

Students will examine commonalities among careers within this field, such as sonographer, air traffic controller, optician, photographer, cosmos, and physical therapist. Then, they will research careers that use waves as a necessary aspect of their typical duties, including career interviews, workplace visits, and navigating company websites. Students will apply this information to their plan for education and training through high school and beyond.

## COMMON MISCONCEPTIONS

Students often think that:

- **Waves transport matter**.
- There must be a medium for a wave to travel through.
- Waves do not have energy.
- All waves travel the same way.
- Frequency is connected to loudness for all amplitudes.
- Big waves travel faster than small waves in the same medium.
- Different colors of light are different types of waves.
- Pitch is related to intensity.
- Light just is and has no origin.
- Light is a particle.
- Light is a mixture of particles and waves.
- Light waves and radio waves are not the same thing.
- In refraction, the characteristics of light change.
- The speed of light never changes.
- Rays and wave fronts are the same thing.
- There is no interaction between light and matter.
- The addition of all colors of light yields black.
- Double slit interference shows light wave crest and troughs.
- Light exits in the crest of a wave and dark in the trough.
- In refraction, the frequency (color) of light changes.
- Refraction is the bending of waves.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

"**Teaching High School Science**" is a series of videos-on-demand produced by Annenberg that show classroom strategies for implementing inquiry into the high school classroom. While not all of the content is aligned to physical science, the strategies can be applied to any content.

BACK TO INDEX

BACK TO PHYSICS OUTLINE

## CONTENT ELABORATION: ELECTRICITY AND MAGNETISM

### Electricity and Magnetism

In earlier grades, the following concepts were addressed: conceptual treatment of electric and magnetic potential energy; the relative number of subatomic particles present in charged and neutral objects; attraction and repulsion between electrical charges and magnetic poles; the concept of fields to conceptually explain forces at a distance; the concepts of current, potential difference (voltage) and resistance to explain circuits conceptually; and connections between electricity and magnetism as observed in electromagnets, motors and generators. In this course, the details of electrical and magnetic forces and energy are further explored and can be used as further examples of energy and forces affecting motion.

- **Charging Objects (friction, contact and induction)**
  For all methods of charging neutral objects, one object/system ends up with a surplus of positive charge and the other object/system ends up with the same amount of surplus of negative charge. This supports the law of conservation of charge that states that charges cannot be created or destroyed. Tracing the movement of electrons for each step in different ways of charging objects (rubbing together two neutral materials to charge by friction; charging by contact and by induction) can explain the differences between them. When an electrical conductor is charged, the charge "spreads out" over the surface. When an electrical insulator is charged, the excess or deficit of electrons on the surface is localized to a small area of the insulator.

  There can be electrical interactions between charged and neutral objects. Metal conductors have a lattice of fixed positively charged metal ions surrounded by a "sea" of negatively charged electrons that flow freely within the lattice. If the neutral object is a metal conductor, the free electrons in the metal are attracted toward or repelled away from the charged object. As a result, one side of the conductor has an excess of electrons and the opposite side has an electron deficit. This separation of charges on the neutral conductor can result in a net attractive force between the neutral conductor and the charged object. When a charged object is near a neutral insulator, the electron cloud of each insulator atom shifts position slightly so it is no longer centered on the nucleus. The separation of charge is very small, much less than the diameter of the atom. Still, this small separation of charges for billions of neutral insulator particles can result in a net attractive force between the neutral insulator and the charged object.
- **Coulomb's law**
  Two charged objects, which are small compared to the distance between them, can be modeled as point charges. The forces between point charges are proportional to the product of the charges and inversely proportional to the square of the distance between the point charges [$F_e = k_e q_1 q_2) / r^2$]. Problems may be solved for the electric force, the amount of charge on one of the two objects or the distance between the two objects. Problems also may be solved for three- or four-point charges in a line if the vector sum of the forces is zero. This can be explored experimentally through computer simulations. Electric forces acting within and between atoms are vastly stronger than the gravitational forces acting between the atoms. However, gravitational forces are only attractive and can accumulate in massive objects to produce a large and noticeable effect whereas electric forces are both attractive and repulsive and tend to cancel each other out.
- **Electric Fields and Electric Potential Energy**
  The strength of the electrical field of a charged object at a certain location is given by the electric force per unit charge experienced by another charged object placed at that location, $E = F_e / q$. This equation can be used to calculate the electric field strength, the electric force or the electric charge. However, the electric field is always there, even if the object is not interacting with anything else. The direction of the electric field at a certain location is parallel to the direction of the electrical force on a positively charged object at that location. The electric field caused by a collection of charges is equal to the vector sum of the electric fields caused by the individual charges (superposition of charge). This topic can be explored experimentally through computer simulations. Greater electric field strengths result in larger electric forces on electrically charged objects placed in the field. Electric fields can be represented by field diagrams obtained by plotting field arrows at a series of locations. Electric field diagrams for a dipole, two-point charges (both positive, both negative, one positive and one negative) and parallel capacitor plates are included. Field line diagrams are excluded from this course.

  The concept of electric potential energy can be understood from the perspective of an electric field. When two attracting or repelling charges interact, the kinetic energies of both objects change but neither is acting as the energy source or the receiver. Instead, the energy is transferred into or out of the electric field around the system as electric potential energy. A single charge does not have electric potential energy. Only the system of attracting or repelling charges can have electric potential energy. When the distance between the attracting or repelling charges changes, there is a change in the electric potential energy of the system. When two opposite charges are moved farther apart or two like charges are moved close together, energy is transferred into the field as electric potential energy. When two opposite charges are moved closer together or two like charges are moved far apart, electric potential energy is transferred out of the field. When a charge is transferred from one object to another, work is required to separate the positive and negative charges. If there is no change in kinetic energy and no energy is transferred out of the system, the work increases the electric potential energy of the system.
- **DC circuits**
  Once a circuit is switched on, the current and potential difference are experienced almost instantaneously in all parts of the circuit even though the electrons are only moving at speeds of a few centimeters per hour in a current-carrying wire. It is the electric field that travels instantaneously through all parts of the circuit, moving the

BACK TO INDEX

BACK TO PHYSICS OUTLINE

electrons that are already present in the wire. Since electrical charge is conserved, in a closed system such as a circuit, the current flowing into a branch point junction must equal the total current flowing out of the junction (junction rule).

Resistance is measured in ohms and has different cumulative effects when added to series and parallel circuits. The potential difference, or voltage ($\Delta V$), across an energy source is the potential energy difference ($\Delta E$) supplied by the energy source per unit charge ($q$) ($\Delta V = \Delta E/q$). The electric potential difference across a resistor is the product of the current and the resistance ($\Delta V = I R$). In physics, only ohmic resistors will be studied. When potential difference vs. current is plotted for an ohmic resistor, the graph will be a straight line and the value of the slope will be the resistance. Since energy is conserved for any closed loop, the energy put into the system by the battery must equal the energy that is transformed by the resistors (loop rule). For circuits with resistors in series, this means that $\Delta V_{battery} = \Delta V_1 + \Delta V_2 + \Delta V_3 + \ldots$. The rate of energy transfer (power) across each resistor is equal to the product of the current through and the voltage drop across each resistor ($P = \Delta V I$) and $P_{battery} = I \Delta V_1 + I \Delta V_2 + I \Delta V_3 + \ldots = I \Delta V_{battery}$. Equations should be understood conceptually and used to calculate the current or potential difference at different locations of a parallel, series or mixed circuit. However, the names of the laws (e.g., Ohm's law, Kirchoff's loop law) will not be assessed. Measuring and analyzing current, voltage and resistance in parallel, series and mixed circuits must be provided. This can be done with traditional laboratory equipment and through computer simulations.

- **Magnetic Fields and Energy**
  The direction of the magnetic field at any point in space is the equilibrium direction of the north end of a compass placed at that point. Magnetic fields can be represented by field diagrams obtained by plotting field arrows at a series of locations. Field line diagrams are excluded from this course. Calculations for the magnetic field strength are not required at this grade level, but it is important to note that greater magnetic fields result in larger magnetic forces on magnetic objects or moving charges placed in the field. The concept of magnetic potential energy can be understood from the perspective of a magnetic field. When two attracting or repelling magnetic poles interact, the kinetic energies of both objects change but neither is acting as the energy source or the receiver. Instead, the energy is transferred into or out of the magnetic field around the system as magnetic potential energy. A single magnetic pole does not have magnetic potential energy. Only the system of attracting or repelling poles can have magnetic potential energy. When the distance between the attracting or repelling poles changes, there is a change in the magnetic potential energy of the system. When two magnetically attracting objects are moved farther apart or two magnetically repelling objects are moved close together, energy is transferred into the field as magnetic potential energy. When two magnetically attracting objects are moved closer together or two magnetically repelling objects are moved far apart, magnetic potential energy is transferred out of the field. Work is required to separate two magnetically attracting objects. If there is no change in kinetic energy and no energy is transferred out of the system, the work done on the system increases the magnetic potential energy of the system. In this course, the concepts of magnetic fields and magnetic potential energy will not be addressed mathematically.
- **Electromagnetic Interactions**
  Magnetic forces are very closely related to electric forces. Even though they appear to be distinct from each other, they are thought of as different aspects of a single electromagnetic force. A flow of charged particles (including an electric current) creates a magnetic field around the moving particles or the current carrying wire. Motion in a nearby magnet is evidence of this field. Electric currents in Earth's interior give Earth an extensive magnetic field, which is detected from the orientation of compass needles. The motion of electrically charged particles in atoms produces magnetic fields. Usually these magnetic fields in an atom are randomly oriented and therefore cancel each other out. In magnetic materials, the subatomic magnetic fields are aligned, adding to give a macroscopic magnetic field.

  A moving charged particle interacts with a magnetic field. The magnetic force that acts on a moving charged particle in a magnetic field is perpendicular to both the magnetic field and to the direction of motion of the charged particle. The magnitude of the magnetic force depends on the speed of the moving particle, the magnitude of the charge of the particle, the strength of the magnetic field, and the angle between the velocity and the magnetic field. There is no magnetic force on a particle moving parallel to the magnetic field. Calculations of the magnetic force acting on moving particles are not required at this grade level. Moving charged particles in magnetic fields typically follow spiral trajectories since the force is perpendicular to the motion.

  A changing magnetic field creates an electric field. If a closed conducting path, such as a wire, is in the vicinity of a changing magnetic field, a current may flow through the wire. A changing magnetic field can be created in a closed loop of wire if the magnet and the wire move relative to one another. This can cause a current to be induced in the wire. The strength of the current depends upon the strength of the magnetic field, the velocity of the relative motion and the number of loops in the wire. Calculations for current induced in a wire or coil of wire is not required at this level. A changing electric field creates a magnetic field and a changing magnetic field creates an electric field. Thus, radiant energy travels in electromagnetic waves produced by changing the motion of charges or by changing magnetic fields. Therefore, electromagnetic radiation is a pattern of changing electric and magnetic fields that travel at the speed of light.

  The interplay of electric and magnetic forces is the basis for many modern technologies that convert mechanical energy to electrical energy (generators) or electrical energy to mechanical energy (electric motors) as well as devices that produce or receive electromagnetic waves. Therefore, coils of wire and magnets are found in many electronic devices including speakers, microphones, generators

BACK TO INDEX

BACK TO PHYSICS OUTLINE

and electric motors. The interactions between electricity and magnetism must be explored in the laboratory setting. Experiments with the inner workings of motors, generators and electromagnets must be conducted. Current technologies using these principles must be explored.

## EXPECTATIONS FOR LEARNING: COGNITIVE DEMANDS

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

## VISIONS INTO PRACTICE

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

- Design and build a generator that will convert mechanical energy into electrical energy. Draw a labeled design plan and write a paper explaining in detail and in terms of electromagnetic induction how the details of the design allow the generator to work. Test the generator in an electric circuit. If it cannot supply the electrical energy to light three flashlight bulbs in a series, redesign the generator.
- Use a source of constant voltage to plan and conduct an experiment to determine the relationship between the current and the resistor in a simple DC circuit. Analyze the results mathematically and graphically. Form a claim about the relationship between the current and resistance and support the claim with evidence from the investigation.

## INSTRUCTIONAL STRATEGIES AND RESOURCES

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

- The equations for gravitational force and electrostatic force can be compared to determine similarities and differences between them.
- "**Circuit Construction Kit**" is interactive simulation produced by PhET that allows students to design and build circuits with resistors, light bulbs, batteries and switches; take measurements with the realistic ammeter and voltmeter; and view the circuit as a schematic diagram or a life- like view.
- "**Battery-Resistor Circuit**" is an interactive simulation produced by PhET that allows students to look inside a resistor to see how it works. The battery voltage can be increased to make more electrons flow though the resistor. The resistance can be increased to inhibit the flow of electrons. The current and resistor temperature change with changing voltage and resistance.
- "**5 Types of Microphones**" from Discovery Company's How Things Work describes how different kinds of microphones are built and how they convert sound to electrical signals.
- "**How Speakers Work**" from Discovery Company's How Things Work describes how speakers are built and how they convert electrical signals to sound.
- "**How Electric Motors Work**" from Discovery Company's How Things Work describes how motors can use magnets to convert electrical energy to mechanical energy.
- "**Direct Current Electric Motor**" by Walter Fendt is an animation that shows the construction of a simple DC electric motor that can be shown to students to explain how it works.
- "**Generator**" by Walter Fendt is an animation that shows the construction of a simple generator that can be shown to students to explain how it works.

BACK TO INDEX

BACK TO PHYSICS OUTLINE

## COMMON MISCONCEPTIONS

Students often think that:

- **A moving charge** will always follow a field line as it accelerates.
- If a charge is not on a field line, it feels no force.
- Field lines are real.
- Coulomb's law applies to charge systems consisting of something other than point charges.
- A charged body has only one type of charge.
- The electric field and force are the same thing and in the same direction.
- Forces at a point exist without a charge there.
- Field lines are paths of a charges motion.
- The electric force is the same as the gravitational force.
- Charge is continuous and can occur in any amount.
- An electron is pure negative charge with no mass.
- Voltage flows through a circuit.
- There is no connection between voltage and electric field.
- Voltage is energy.
- High voltage by itself is dangerous.
- Charges move by themselves.
- Designations of (+) and (-) are absolute.
- Resistors consume charge.
- Electrons move quickly (near the speed of light) through a circuit.
- Charges slow down as they go through a resistor.
- Current is the same thing as voltage.
- There is no current between the terminals of a battery.
- The bigger the container, the larger the resistance.
- A circuit does not have form a closed loop for current to flow.
- Current gets "used up" as it flows through a circuit.
- A conductor has no resistance.
- The resistance of a parallel combination is larger than the largest resistance.
- Current is an excess charge.
- Charges that flow in circuit are from the battery.
- The bigger the battery, the more voltage.
- Power and energy are the same thing.
- Batteries create energy out of nothing.
- North and south magnetic poles are the same as positive and negative charges.
- Poles can be isolated.
- Magnetic fields are the same as electric fields.
- Charges at rest can experience magnetic forces.
- Magnetic fields from magnets are not caused by moving charges.
- Generating electricity requires no work.
- When generating electricity only the magnet can move.
- Voltage can only be induced in a closed circuit.
- Water in dams causes electricity.

## DIVERSE LEARNERS

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

## CLASSROOM PORTALS

"**Teaching High School Science**" is a series of videos-on-demand produced by Annenberg that show classroom strategies for implementing inquiry into the high school classroom. While not all of the content is aligned to physical science, the strategies can be applied to any content.