Ohio's Learning Standards and Model Curriculum

Science

STANDARDS ADOPTED FEBRUARY 2018
MODEL CURRICULUM ADOPTED MAY 2019

Ohio | Department of Education

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Introduction

OVERVIEW

This overview outlines the visions and goals of *Ohio's Learning Standards and Model Curriculum for Science*, provides the guiding principles that framed the development of the materials and contains the definitions used in the document. The *Expectations for Learning* encompasses the *Nature of Science* and the *Cognitive Demands*. This overview introduces the *Nature of Science,* which is the foundation for all aspects of science instruction. It also contains definitions for the *Cognitive Demands*.

VISION

Each Child, Our Future is Ohio's five-year strategic plan to ensure each student enjoys a bright future thanks to an excellent preK-12 education experience. The plan's vision is for each child to be *challenged* to discover and learn, *prepared* to pursue a fulfilling post-high school path and *empowered* to become a resilient, lifelong learner who contributes to society.

The strategic plan details four equal learning domains that contribute to the holistic success of each child. These include foundational knowledge and skills, well-rounded content, leadership and reasoning skills and social-emotional learning. *Ohio's Learning Standards and Model Curriculum for Science* support the four domains.

Ohio's Learning Standards and Model Curriculum for Science serves 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 at each grade level. From this information, district curriculum can be developed. 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]

[1]*Taking Science to School Learning and Teaching Science in Grades K-8.* National Research Council of the National Academies.

> "Knowledge of science can enable us to think critically and frame productive questions. Without scientific knowledge, we are wholly dependent on others as "experts." With scientific knowledge, we are empowered to become participants rather than merely observers. Science, in this sense, is more than a means for getting ahead in the world of work. It is a resource for becoming a critical and engaged citizen in a democracy."
> Michaels, S., Shouse, A.W., & Schweingruber H. A. (2008). *Ready, Set, SCIENCE!* Washington DC: The National Academies Press.

The K-8 and high school sections 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* incorporates the *Nature of Science* and the *Cognitive Demands*. 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 grade level materials.

It is the blending of the *Content Statements* and *Content Elaborations* with the *Expectations for Learning* (*Cognitive Demands* and *Nature of Science*) that provides 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 of Ohio law.

GUIDING PRINCIPLES

Ohio's Learning Standards and Model Curriculum for Science has been informed by international and national studies, education stakeholders and academic content experts. The guiding principles include:

- **Definition of Science:** Scientific knowledge is logical, predictive and testable, and expands and advances as new evidence is discovered. Science is a process 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.
- **Scientific and Engineering Practices:**
  1. Asking questions (for science) and defining problems (for engineering)
  2. Developing and using models
  3. Planning and carrying out investigations
  4. Analyzing and interpreting data
  5. Using mathematics and computational thinking
  6. Constructing explanations (for science) and designing solutions (for engineering)
  7. Engaging in argument from evidence
  8. Obtaining, evaluating, and communicating information[3]

[3] National Research Council. 2012. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, DC: The National Academies Press.

- **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 ORC 3301.079, 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.
- **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 this 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* provides the means by which students can demonstrate this grade-level mastery.
- **Internationally Benchmarked:** *Ohio's Learning Standards and Model Curriculum for Science* incorporates 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).17

  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:** *Ohio's Learning Standards and Model Curriculum* provides a framework from which local curricula can be developed. It is not the curriculum. The curriculum will continue to be a local responsibility.

FORMAT AND DEVELOPMENT OF THE STANDARDS AND MODEL CURRICULUM

Ohio's Learning Standards and Model Curriculum is a web-based resource that identifies the content to be instructed and provides examples for implementation in science classrooms through *Expectations for Learning* and the accompanying *Visions into Practice*. While this document focuses on what is most essential, it does not describe all that teachers can or should teach. Teachers and curriculum developers maintain a great deal of discretion in this area.

Work on revision of the standards and model curriculum took place between November 2016 and December 2018, with input from numerous stakeholders from around the state. Three surveys collected input from the public, and more than 175 individuals contributed to updating this document based on survey comments. Various professional and industrial organizations related to science sent representatives to serve on an advisory group overseeing the standards revision process.

The goal of these changes is to improve science education in grades K-12 by providing clarity, focus and a logical, vertical progression in each discipline. All Ohio students deserve rigorous, scientifically accurate instruction that makes them college or career ready and scientifically literate members of society. These standards and model curriculum serve as a road map for Ohio science teachers to use as they customize instruction to fit the individual needs of their particular students. Additional instructional supports will be made available over time.

TRANSITION PERIOD

Ohio's Learning Standards for Science will be fully implemented in the 2020-2021 school year to allow educators time to align instruction and resources to the revised standards.

Teachers can begin to transition to the new materials by becoming familiar with the *Nature of Science* and the updated *Visions into Practice,* along with updates to the *Standards* and *Content Elaborations*. The *Nature of Science* distinguishes science as a discipline and describes how scientific knowledge is advanced. This section includes guidelines that contribute to the development of scientific literacy for all students. It is a knowledge of the constructs and values that are intrinsic to science. This material needs to be embedded continuously with all content. *Visions into Practice* provides examples for the *Expectations for Learning* framed by the *Cognitive Demands*. All components of the *Model Curriculum* are compatible with the 5E Learning Cycle (see page 6).

Scientific and engineering practices incorporate universal skills, such as collaboration, critical thinking, problem-solving, communication, research and meta-cognition that are commonly thought of as 21st century process skills. Engaging students in these practices allows them to learn and demonstrate both scientific, technological and engineering design skills that address the goals of career and college readiness.

5E LEARNING CYCLE

By using the 5E Learning Cycles teachers will be able to:

- Provide supports to students as they learn to frame questions, assess and analyze data, and create and critique explanations (including engaging with others in a public forum) – all important components of scientific and engineering practices.
- Select instructional materials that promote the teaching and learning of science by using scientific and engineering practices.
- Assess students' abilities in multiple ways that are compatible with scientific and engineering practices.

Students engaging with grade-appropriate science content through scientific and engineering practices and the 5E Learning Cycle will be better prepared to meet the challenges as they enter higher education or pursue careers.

Model Curriculum Definitions

Strands: Earth and space sciences; physical sciences; and life sciences The Nature of Science is an umbrella over all the content standards and is embedded in each stand.

Grade Band Themes: These are the overarching ideas that connect the strands and 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: These 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 Ohio Department of Education-recommended sequence as there is no recommended sequence.*

Model Curriculum: The model curriculum is a web-based resource that incorporates information on "how" the material in the content statement may be taught. It includes content elaborations and learning expectations.

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 includes *Ohio's Cognitive Demands for Science* and the *Nature of Science*. The *Nature of Science* distinguishes science as a discipline and describes how scientific knowledge is advanced. This section includes guidelines that contribute to the development of scientific literacy for all students. It is a knowledge of the constructs and values that are intrinsic to science. This material needs to be embedded continuously within all content. *Ohio's Cognitive Demands for Science* 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, monitor observable evidence of student learning and develop summative assessment of student learning of science. The cognitive demands include designing technological and engineering solutions using science concepts, demonstrating science knowledge, interpreting and communicating science concepts and recalling accurate science. *Visions into practice* provide examples of how to implement the cognitive demands.

Table 1: Nature of Science

Nature of Science One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.	
Categories	**K-2**
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Apply knowledge of science content to real-world challenges. • Plan and conduct simple scientific investigations using appropriate safety techniques based on explorations, observations and questions. • Employ simple equipment and tools to gather data and extend the senses. • Use data and mathematical thinking to construct reasonable explanations. • Communicate with others about investigations and data.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past, and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• The world is discovered through exploration. • Exploration leads to observation. Observation leads to questions. • Natural events happen today as they happened in the past. • Events happen in regular patterns and cycles in the natural world.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Everyone explores the world which generates questions. • The answer is not always as important as the process. • Questions often lead to other questions. • Discoveries are communicated and discussed with others. • People address questions through collaboration with peers and continued exploration. • Everyone can see themselves as scientists.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• It is essential to learn how to identify credible scientific evidence. • Ideas are revised based on new, credible scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Table 1: Nature of Science (continued)

Nature of Science One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.	
Categories	**3-5**
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Observe and ask questions about the world that can be answered through scientific investigations. • Design and conduct scientific investigations using appropriate safety techniques. • Use appropriate mathematics, tools and techniques to gather data and information. • Develop and communicate descriptions, models, explanations and predictions. • Think critically and ask questions about the observations and explanations of others. • Communicate scientific procedures and explanations. • Apply knowledge of science content to real-world challenges.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• Science is both a body of knowledge and processes to discover new knowledge. • Science is a way of knowing about the world around us based on evidence from experimentation and observations. • Science assumes that objects and events occur in consistent patterns that are understandable through measurement and observation.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• People from many generations and nations contribute to science knowledge. • People of all cultures, genders, and backgrounds can pursue a career in science. • Scientists often work in teams. • Science affects everyday life. • Science requires creativity and imagination.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science develops theories based on a body of scientific evidence. • Science explanations can change based on new scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Table 1: Nature of Science (continued)

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	6-8
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Apply knowledge of science content to real-world challenges. • Identify questions that can be answered through scientific investigations. • Design and conduct scientific investigations using appropriate safety techniques. • 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. • Communicate scientific procedures and explanations. • Design technological/engineering solutions.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• Science is a way of knowing about the world around us based on evidence from experimentation and observations. • Science is a continual process and the body of scientific knowledge continues to grow and change. • Science assumes that objects and events occur in consistent patterns that are understandable through measurement and observation. • Science should carefully consider and evaluate all data including outliers. • Science is based on observable phenomena and empirical evidence. • Science disciplines share common rules for obtaining and evaluating empirical evidence.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Individuals from different social, cultural, and ethnic backgrounds work as scientists and engineers. • Scientists and engineers are guided by habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism and openness to ideas. • Scientists and engineers rely on human qualities such as persistence, precision, reasoning, logic, imagination and creativity.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science explanations are subject to revision and improvement in light of additional scientific evidence or new understanding of scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Table 1: Nature of Science (continued)

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	High School
Scientific Inquiry, Practice and Applications All students must use these 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 using a variety of methods and tools to collect empirical evidence, observing appropriate safety techniques. • Use technology and mathematics to improve investigations and communications. • Formulate and revise explanations and models using logic and scientific evidence (critical thinking). • Recognize and analyze explanations and models. • Communicate and support scientific arguments.

Science is a Way of Knowing
Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.
	• Various science disciplines use diverse methods to obtain evidence and do not always use the same set of procedures to obtain and analyze data (i.e., there is no one scientific method).
	  o Make observations and look for patterns.
	  o Determine relevant independent variables affecting observed patterns.
	  o Manipulate an independent variable to affect a dependent variable.
	  o Conduct an experiment with controlled variables based on a question or hypothesis.
	  o Analyze data graphically and mathematically.
	• Science disciplines share common rules of evidence used to evaluate explanations about natural phenomenon by using empirical standards, logical arguments and peer reviews.
	  o Empirical standards include objectivity, reproducibility, and honest and ethical reporting of findings.
	  o Logical arguments should be evaluated with open-mindedness, objectivity and skepticism.
	• Science arguments are strengthened by multiple lines of evidence supporting a single explanation.
	• The various scientific disciplines have practices, methods, and modes of thinking that are used in the process of developing new science knowledge and critiquing existing knowledge.

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	High School
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Science depends on curiosity, imagination, creativity and persistence. • Individuals from different social, cultural, and ethnic backgrounds work as scientists and engineers. • Science and engineering are influenced by technological advances and society; technological advances and society are influenced by science and engineering. • Science and technology might raise ethical, social and cultural issues for which science, by itself, does not provide answers and solutions.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science can advance through critical thinking about existing evidence. • Science includes the process of comparing patterns of evidence with current theory. • Some science knowledge pertains to probabilities or tendencies. • Science should carefully consider and evaluate anomalies (persistent outliers) in data and evidence. • Improvements in technology allow us to gather new scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Table 2: Ohio's Cognitive Demands for Science

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 practices 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)
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. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.
RECALLING ACCURATE SCIENCE (R)	Requires student 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.

As with all other frameworks and cognitive demand systems, Ohio's 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.

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 for promoting understanding of interactions within and between systems and explaining and predicting 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 still can 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.

TOPICS BY GRADE LEVEL

SCIENCE INQUIRY, PRACTICES AND APPLICATIONS
During the years of **K to grade 4**, all students must develop the ability to: 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.

THEMES	GRADE	THE PHYSICAL SETTING		THE LIVING ENVIRONMENT
		EARTH AND SPACE SCIENCE	PHYSICAL SCIENCE	LIFE SCIENCE
Observations of the Environment 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.		
		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 environments in which they live.		
		The Atmosphere	**Changes in Motion**	**Interactions within Habitats**
Interconnections within Systems 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 living and nonliving 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 for materials and energy. 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**

SCIENCE INQUIRY AND APPLICATIONS
During the years of **grades 5 through 8**, all students must have developed the ability to: 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.

THEMES	GRADE	THE PHYSICAL SETTING		THE LIVING ENVIRONMENT
		EARTH AND SPACE SCIENCE	**PHYSICAL SCIENCE**	**LIFE SCIENCE**
Interconnections within Systems This theme focuses on helping students explore the components of various systems and then investigate dynamic and sustainable relationships within systems using scientific inquiry.	**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.		
		Cycles and Patterns in the Solar System	**Light, Sound and Motion**	**Interactions within Ecosystems**
Order and Organization 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 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**

Ohio's Learning Standards for Science

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 natural world around them in greater depth by using scientific inquiry.

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 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** 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** This topic focuses on observing, exploring, describing and comparing living things in Ohio.
CONDENSED CONTENT STATEMENTS		
K.ESS.1: Weather changes are long-term and short-term. **K.ESS.2:** The moon, sun and stars can be observed at different times of the day or night.	**K.PS.1:** Objects and materials can be sorted and described by their properties. **K.PS.2:** Some objects and materials can be made to vibrate and produce sound.	**K.LS.1:** Living things have specific characteristics and traits. **K.LS.2:** Living things have physical traits and behaviors, which influence their survival.

NATURE OF SCIENCE GRADES K-2

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	K-2
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Apply knowledge of science content to real-world challenges. • Plan and conduct simple scientific investigations using appropriate safety techniques based on explorations, observations and questions. • Employ simple equipment and tools to gather data and extend the senses. • Use data and mathematical thinking to construct reasonable explanations. • Communicate with others about investigations and data.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past, and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• The world is discovered through exploration. • Exploration leads to observation. Observation leads to questions. • Natural events happen today as they happened in the past. • Events happen in regular patterns and cycles in the natural world.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Everyone explores the world which generates questions. • The answer is not always as important as the process. • Questions often lead to other questions. • Discoveries are communicated and discussed with others. • People address questions through collaboration with peers and continued exploration. • Everyone can see themselves as scientists.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• It is essential to learn how to identify credible scientific evidence. • Ideas are revised based on new, credible scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Complete *Nature of Science* document is found on pages 8-12.

Kindergarten continued

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

K.ESS.1: 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 7.*

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 may be marked on a dowel rod to check the depth.

Weather measurements should 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 study weather events, record classroom data, compare classroom data to local data, communicate and share data with other classrooms.

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 agents 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 7.

EXPECTATIONS FOR LEARNING

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Weather station			
As a class, make a portable weather station that can measure wind, temperature and precipitation amounts. Test and select the best location for the weather station (so that accurate readings can be collected). Design and build a device to measure rainfall amounts. This can be done individually or as a class.	Test different methods or tools to collect precipitation amounts (rain, snow or ice), and measure the speed (faster or slower) and direction of wind (which way the wind is blowing). Ask questions about what happens next, such as: When the wind increases, what happens to the temperature? **Note:** *Nonstandard measurements can be used to meet this objective (e.g., using a dowel to measure the depth of snow).*	Graph weather measurements over time and discuss any patterns that emerge. Graphs can be saved to compare the weather trends of each season. Create an in-class weather station data display center as a place to document the daily weather.	Recognize that temperature, wind and precipitation are aspects of weather that can be measured. Identify the four seasons and the temperature and precipitation measurements that characterize each season. Dress a character appropriately for the day's weather.
Bubbles in the wind			
	Compare the speed (fast, slow) and direction of the wind in different outside areas. Create an investigation, using bubbles to discover there is wind energy, even though you cannot normally see it.	Create a poster or other graphic demonstrating which way the bubbles were blowing. Compare and discuss what was happening.	Explain the connection between wind energy and bubble movement (i.e., the wind determines the direction and speed the bubbles move).

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Weather walks Take weather walks during or after different weather events.			
	Create an investigation highlighting different weather events (e.g., sun casting shadows, wind socks to measure wind, puddles of water after a rain)	Keep a journal of observations on the walks. Draw pictures of the weather observations. Discuss and compare different walks (seasonal).	Describe different types of weather (seasonal characteristics).

Kindergarten continued

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

K.ESS.2: The moon, sun and stars can be observed at different times of the day or night.

The moon, sun and stars appear 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 the month. The sun is visible only during the day.

The sun's position in the sky appears to change 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 can also 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 that can be observed are included. At times, the moon can be observed in the daylight. 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) can 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 sun is the only star in the solar system and celestial bodies orbit the sun.

Grades 6-8: The tilt and orbit of Earth and position of the sun are related to the seasons.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Sun and shadows			
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. Place the garden based on sun-shadow data (see demonstrating science knowledge). The design should be drawn on a map and discussed by 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? 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 positions of the sun throughout day and in the different seasons. Present findings orally and/or graphically.	Recognize that the sun changes position in the sky during the day.
Sundial clock			
Design and create a sundial to place outside.	Using a sundial clock, create an experiment or activity to discover and interpret changes in the shadow.	Create a table or chart (e.g., sundial plot, shadow plot) to document changes in shadows throughout the day. Discuss the reasons for the changes.	
Day and night			
	Create an investigation to discover why the sun is only visible in the day (e.g., globe and flashlight).	Observe the sky during the day and night and record what is observed. Compare and discuss similarities and differences of the daytime sky and nighttime sky. Make drawings of the sky at different times during the day and year. Monthly, discuss changes and compare charts from fall, winter, spring and summer. 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.	Identify the season with the most and least amount of daylight hours. Discuss how and why the daytime and nighttime skies are different.

Kindergarten continued

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	CONTENT ELABORATION
K.PS.1: 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.	**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. Students should not use the sense of taste as a way of observing an unknown substance. Observations are limited to descriptors such as hot, warm, cold, heavy and light. Comparisons of objects are a precursor to measurement. Comparisons are 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 can be explored and investigated. **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. 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. Differentiating between mass and weight is not necessary at this grade level.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Properties of materials			
Design and create a house that can survive strong winds (e.g., the big bad wolf). Provide building materials (e.g., tape, different sized craft sticks, cardboard, pipe cleaners, cereal boxes, feathers, straws). Compare classroom designs and determine which design feature can withstand the strongest winds (fan speed).	Use standard or nonstandard measurements to compare and order objects (e.g., heavier, longer).	Use observable (touch, sight, hearing, smell) information to categorize items by creating a system of organization using one or more physical properties such as size, shape, color, texture, smell and weight. Create a visual representation, using pictures and/or words to explain the sort.	Describe different properties of objects.

Kindergarten continued

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	CONTENT ELABORATION
K.PS.2: 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.	**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 as water splashes when a cymbal or triangle is placed in water or when rice vibrates on the top of a banging drum. The concepts of pitch (low vs. high notes) and volume (loudness) are introduced. Sound needs to be experienced, investigated and explored through observations and experimentation. Standard, virtual and student-constructed instruments can be used to explore sound. Wave descriptions of sound and the propagation of sound energy are not appropriate at this grade level. **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

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Sound			
Design and make an instrument that can produce different sounds by tapping, plucking or blowing. Evaluate the set of instruments created and make suggestions on how the instruments may make different types of sounds. Design and create a sound garden (e.g., wind chime) using a variety of materials such as plastic, wood and metal.	Explore different ways sounds can be made from an object (e.g., horn, cymbals, rubber band, guitar, plastic bottle). Investigate different amounts of water in cups of the same size and shape to illustrate different sounds. Investigate how the amount of stretch of plucked rubber bands affects the sound. Investigate how different materials or combinations of materials make different sounds.	Compare different ways to make loud and soft sounds by tapping, blowing or plucking objects. Compare different sounds and describe how the tones are different. Observe and listen to a sound garden on a rainy day, windy day and sunny day. Discuss any differences.	Identify three ways to make sounds from objects. Explain that vibrating materials make sounds. Describe ways to change the loudness of a sound (e.g., blow more air through a whistle, bang harder on a drum).

Kindergarten continued

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	CONTENT ELABORATION
K.LS.1: Living things have specific characteristics and traits. Living things grow and reproduce. Living things are found worldwide.	**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. Nonliving things often share some characteristics with living things (e.g., a fire uses energy and grows). Simply listing the characteristics that distinguish living things from nonliving things is not appropriate at this grade level. 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 grow, reproduce, require energy and respond to stimuli. Animals need food for energy; plants acquire energy from the sun. Living things respond to stimuli (e.g., fish in an aquarium respond to the addition of food). Living things grow (e.g., seedlings placed in soil grow). Conduct experiments and explorations to observe what happens when plants are placed in different classroom habitats (e.g., on the floor, in a closet, on a desk). Some observations can also be done virtually. When studying living things, ethical treatment of animals, safety procedures and proper hygiene 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. **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

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Nature investigations			
	Observe nature in a variety of ecosystems, multiple times a year. Record the different plants and animals found and patterns that emerge throughout the year. Design an investigation to document plant growth.	Draw or take pictures as a plant grows (e.g., draw pictures each day of a bud of a flowering plant to document its growth). Document and describe the living things found in an area.	Describe characteristics and traits of a living thing in the home or school habitat.
Classroom living organism			
Design a habitat that will support a classroom pet or plant. Provide for all its needs including, but not limited to food, water, air, shelter, cleanliness and safety.		Keep a classroom journal or graph documenting the growth of a plant or animal. Alternatives to a classroom pet could include webcams and visits to zoos or parks.	Describe how a chosen organism changes as it grows.
Living things grow and reproduce			
	Design an investigation, using student heights, a class pet or webcams, where students watch and document living things as they grow (e.g., find a webcam watching a nest or baby animals and, as a class, take sequential screenshots of the babies).	Create a collage of animals connecting adults and offspring. Create a class book of animals and their babies. **Note:** *Neither of these should focus on different life cycles.*	Explain that living things grow and reproduce.

<table>
<tr><th>Designing technological/engineering solutions using science concepts</th><th>Demonstrating science knowledge</th><th>Interpreting and communicating science concepts</th><th>Recalling accurate science</th></tr>
<tr><td colspan="4">Characteristics of plants</td></tr>
<tr><td>Design and plant a native pollinator garden. Make observations of the changes that occur. Observe what animals come to visit and make predictions about the purpose of their visits (e.g., food, shelter).</td><td>Design an investigation to observe how plants grow (e.g., bean seed on a paper towel or dampened cotton).
How does location affect plant growth?
Which direction do a plant's roots and leaves grow?
How will seeds grow after being turned upside down (e.g., after planting seeds in plastic baggies, let them sprout for a few days then turn half the baggies upside down to determine which direction the plants now grow)?</td><td>Draw pictures to document different plants' growth patterns. Use either classroom plants or a flower garden. Create a graph and document growth on a regular basis. Discuss and compare differences among plants.</td><td>Describe how a plant grows.
Explain that a plant's stem and leaves grow toward the sun and its roots grow down.</td></tr>
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<tr><td></td><td>Explore the different types of plants and animals that are found around the world (e.g., visit local zoos, use worldwide webcams or computer sites like National Geographic Kids). Research different animals and plants to determine where they naturally live. Using results from the research, create a classroom map to illustrate that living things are found all over the world.</td><td>Create a class book for regions of the world and document what plants and animals can be found there.</td><td>Explain that living things can be found all over the world.</td></tr>
</table>

Kindergarten continued

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	CONTENT ELABORATION
K.LS.2: Living things have physical traits and behaviors, which influence their survival. Living things are made up of a variety of structures. Some traits can be observable structures. Some of these structures and behaviors influence their survival.	**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 structures of living things but associating through interaction and observation that living things are made of structures, and because of those structures, living things can do specific activities. Identify and discuss examples, such as: birds having wings for flying and beaks for eating; dogs having eyes for seeing, teeth for chewing and legs for moving; trees having leaves to capture sunlight and trunks for support. 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 (focusing on macroscopic organisms), raising a classroom pet (check for student allergies), bird watching, noting differences between different types of plants and planting seeds and watching them grow. **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 specific 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

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
		Nature observations	
Design and create an animal-proof structure (e.g., raccoon proof garbage can, squirrel proof bird feeder).	Choose a focus for observation (e.g., trees, birds, insects). Take note of the physical structures of that living organism and discuss how those structures influence the organism's survival (e.g., wings for flight, placement of eyes, thorns).	Sort collections or drawings of organisms by similar structures. Discuss similarities with classmates. Compare the human heart with the heart shape. Explain what job the heart does. Explore the human sensory system including sight, touch, taste, smell and hearing. Identify the sensory organs and their functions. Identify ways each of these senses helps humans survive.	Give an example of a structure and tell how it helps an organism survive. Identify the major parts of the human body using appropriate names. Describe their functions.
		Insect observations	
	Create a plate of food to attract insects. Take the plate outside and observe what types of insects are attracted. Observe the insects' structures and behaviors. Explore what happens if the plate contains different foods or is placed in a new location.	Observe and document body structure, behavior and numbers of insects visiting an insect food plate. Discuss questions such as: What do insects' bodies look like? How do they move and communicate?	Describe an insect's structure and behavior.
		Bird observations	
	Place birdfeeders around the schoolyard with different types of seed/food in each. Observe which birds are attracted to each feeder. Observe the birds' structures and behaviors.	Observe and document body structure, behavior, and numbers of birds visiting a feeder. Discuss questions such as: How are the beaks of different birds similar or different? How do birds react to one another? Is the feeding behavior the same in different seasons?	Describe a bird's structure and behavior.

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 natural world around them in greater depth by using scientific inquiry.

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 This topic focuses on the sun as a source of energy and energy changes that occur to land, air and water.	**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.	**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.
CONDENSED CONTENT STATEMENTS		
1.ESS.1: The sun is the principal source of energy. **1.ESS.2:** Water on Earth is present in many forms.	**1.PS.1:** Properties of objects and materials can change. **1.PS.2:** Objects can be moved in a variety of ways, such as straight, zigzag, circular and back and forth.	**1.LS.1** Living things have basic needs, which are met by obtaining materials from the physical environment. **1.LS.2:** Living things survive only in environments that meet their needs.

NATURE OF SCIENCE GRADES K-2

Nature of Science One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.	
Categories	**K-2**
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Apply knowledge of science content to real-world challenges. • Plan and conduct simple scientific investigations using appropriate safety techniques based on explorations, observations and questions. • Employ simple equipment and tools to gather data and extend the senses. • Use data and mathematical thinking to construct reasonable explanations. • Communicate with others about investigations and data.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past, and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• The world is discovered through exploration. • Exploration leads to observation. Observation leads to questions. • Natural events happen today as they happened in the past. • Events happen in regular patterns and cycles in the natural world.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Everyone explores the world which generates questions. • The answer is not always as important as the process. • Questions often lead to other questions. • Discoveries are communicated and discussed with others. • People address questions through collaboration with peers and continued exploration. • Everyone can see themselves as scientists.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• It is essential to learn how to identify credible scientific evidence. • Ideas are revised based on new, credible scientific evidence.

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Grade 1 continued

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	CONTENT ELABORATION
1.ESS.1: 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.	**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 apparent position of the sun can change. **Grade 1 Concepts** Quantitative measurements are 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 can 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 are used to collect, compare and document data. Investigation and experimentation are 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 Earth and the sun are explored.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Energy from the sun			
Design a structure that will warm soil, water or air (e.g., black paper, funnel shapes, tinfoil). Design a structure that will cool soil, water or air (e.g., create a way to shade the soil, water, air). Design and create a structure that will decrease or increase the rate at which an ice cube melts.	Place cups of soil and water in different areas. Take temperature readings at different times during the day. Demonstrate that energy from the sun heats the soil, water and air. Natural sunlight is preferred over alternate sources such as a lamp in this demonstration. Collect data (e.g., temperature, water, outside weather, amount of daily sunlight) and organize to use in the comparison. Place frozen water in the sun. Periodically measure the temperature and the thawing of the water. Chart the time, temperature and water state. Discuss possible reasons for the change.	Solar energy affects temperature. Measure temperature changes of soil, water and air in different settings and/ or exposures to sunlight. Make a graph, chart or table to record and organize the data.	Identify the sun as a primary source of energy.
Solar device			
Build a device that can collect or use solar energy (e.g., solar oven, solar wind chimes, solar water heating device).	Investigate how different materials absorb or reflect sunlight. Investigate what colors or materials work best, where the device works best and how the device can be changed to work better.		Describe how sunlight affects the heating of objects.
Cold frame			
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 a cold frame to get the most autumn/winter sunlight. Compare the results within the class or from class to class. Collect data (e.g., temperature, water, outside weather, amount of daily sunlight) and organize to use in the comparison.		Recognize that sunlight warms water, air and soil.

Grade 1 continued

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	CONTENT ELABORATION
1.ESS.2: Water on Earth is present in many forms. 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. **Note**: *Water as a vapor is not introduced until grade 2; the water cycle is reserved for later grades.*	**Prior Concepts Related to Water** **PreK-K:** Water can be observed in many different forms. Precipitation (e.g., rain, sleet, hail, 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 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 can also be observed in the air as clouds, steam or fog, but this content should be limited to observation only at this grade level. Investigations (inside or outside) and experimentation are 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.

EXPECTATIONS FOR LEARNING

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
	Water on Earth		
	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 could happen when liquid water gets into rocks and then freezes? Design investigations to demonstrate how varying amounts of water affect the shape of the land. Spritzing, dripping, and pouring could simulate different amounts of rain. Freeze the different samples to demonstrate the effects of freezing and thawing and how that changes the shape of the land. Extend to show the effects using different items for the land (e.g., sand, soil, gravel). Investigate the physical differences (e.g., weight, temperature, texture) between snow or crushed ice and liquid water Ask: How much does one cup of snow/crushed ice/liquid water weigh? How does snow/crushed ice look through a hand lens? Discuss how these findings can apply to weather observations (e.g., how many inches of snow equal one inch of rain?).	Examine maps, globes, models and discuss the amount of land vs. water. Identify water that is solid (ice) and water that is liquid. 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, streams, ponds, oceans, rain, snow, hail, sleet, fog). Explain that heating and cooling water can change it from a solid to a liquid or a liquid to a solid. Explain some ways that water can affect the land.

Grade 1 continued

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	CONTENT ELABORATION
1.PS.1: Properties of objects and materials can change. Objects and materials change when exposed to various conditions, such as heating or cooling. Changes in temperature are a result of changes in energy. Not all materials change in the same way.	**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. Emphasis is placed on observations. Concepts of thermal energy, atoms and heat transfer are not appropriate at this grade level. Some materials are a liquid or solid at room temperature and may change from one form to the other with a change in temperature. A liquid may turn into a solid when cooled. A solid may turn into a liquid when heated. The amount of the material in the solid or liquid remains the same before and after the change. Investigations and experiments (may include virtual investigations) are conducted to explore property changes of objects and materials. **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.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students with opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Solids and liquids			
Design and create a device to increase the rate that a substance melts.	Design an investigation to change a solid into a liquid and back to a solid (e.g., ice to water, popsicle to liquid, melting chocolate chips). Weigh the substance before and after melting to demonstrate the amount does not change, just the shape. Include temperature readings to demonstrate that heat energy caused the change. Investigate what happens to a solid when heat energy is added (e.g., crayon and a blow dryer).	Document and describe properties of a solid (e.g. composition, texture, shape). Document and describe properties of a liquid (e.g. composition, texture, shape). Compare the properties of solids and liquids. Describe changes to the shapes of solids or liquids as you place them into different containers, melt or freeze them. Create a graphic to depict the changes of a solid to a liquid.	Explain what causes properties of objects and materials to change. Explain the properties of solids and liquids.
Changes in properties			
	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. Design an investigation to see how observable properties of solids can change (e.g., tearing, wetting, cutting, pressure application).	Create a graphic to illustrate changes of a material as it changes.	Classify various types of changes that objects or materials can go through to change observable properties (e.g., freezing, melting, tearing, wetting).

Grade 1 continued

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	CONTENT ELABORATION
1.PS.2: 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. Changes in motion are a result of changes in energy.	**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 changed. Objects can move in a straight line (e.g., a dropped coin falling to the ground) or a circle (e.g., a pinwheel) or back and forth (e.g., a swing) or even in a zigzag pattern. Objects near Earth fall to the ground unless something holds them from falling. 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 (e.g., a ball, a pinwheel, a kite) can be used to demonstrate movement. 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 level. **Note:** *Scientific definitions and calculations of speed are not appropriate at this grade level*. **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.

EXPECTATIONS FOR LEARNING

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Zig-zag maze			
Design, construct and test a device that will cause a ping-pong ball to move in a zigzag pattern. Test and evaluate the effectiveness of different devices made by different groups in the class. Redesign the device for greater effectiveness.	Create an investigation with a ball (e.g., ping-pong ball, marble) to demonstrate different paths of motion in a zig-zag pattern.	Explain how the position of the ball changed in a device that causes a ball to move in a zig-zag pattern.	Explain what causes a ball to change the path of its motion.
Ways to change the motion of an object			
	Implement a scientific investigation to determine how a ball can be made to speed up, slow down or change direction. With the class, list all the ways that were found.	Compare the different methods used by different groups in the class.	Illustrate that a push or pull is needed to speed up, slow down or change the direction of a moving object.
Toys			
	Design and create an investigation to discover different paths of motion toys will take.	Sort and chart a variety of toys by their different paths of motion. Represent the different motions of a toy in words, pictures and diagrams.	Describe different paths of motion (e.g., circular, straight, zig-zag).
Playground			
Design and create a model of playground equipment that requires a push or pull to work.		Explain how a piece of playground equipment works (push or pull). Explore playground equipment and categorize those that use a push, a pull or both. Explain the motion and forces (e.g., push or pull) needed to play on a piece of playground equipment.	Identify an object's position with respect to another object.

Grade 1 continued

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

1.LS.1: 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 Environments
PreK-K: Living things are identified in a variety of ecosystems. Living things have physical traits, which enable them to live in different ecosystems.

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. 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. Investigations about the types of living things that live in specific ecosystems 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

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Bird feeders			
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. Compare the feeder usage at different times of the year.	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?*	Based on observations of birds in the field, compare the food choices of birds and create a chart to communicate findings.	
Seasonal nature walks or explorations			
	Make observations outside at least once each season to discover what living things are in an area. Look to see what other things are there that meet the needs of the organisms (e.g., berries on trees, bushes for birds, water source). Compare what is found in various seasons.	Record observations from nature walks (e.g., photos, drawings, journals). Have groups share and discuss findings. Compare with prior explorations of the same area. Compare the ways humans get air, water and food with those of other living things. Include plants and animals that are found in the local community or a given ecosystem.	Identify the basic survival needs of plants and animals (e.g., classroom pets, plants used in classroom experiments, organism observed in nature).

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Ohio wildflower garden			
Research and plant a native wildflower garden to attract birds, butterflies, bees and/or moths.	Seasonally, observe a wildflower garden paying close attention to what animals are attracted to the garden. Record the interactions observed.	Create a pamphlet of which birds, butterflies or moths are attracted to which plants.	Identify what plants, birds, bees and moths need to survive. Explain how those needs are met by the environment.
Classroom habitat exploration			
	Use a terrarium or aquarium to study interactions between organisms. Observe how organisms change throughout the year. Document the changes with photos, drawings or measurements.	Graph plant and animal growth in a classroom habitat. Draw and explain interactions between plants and animals.	Explain that plants get energy from the sun and animals get energy from plants or other animals.

Grade 1 continued

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	CONTENT ELABORATION
1.LS.2: 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.	**Prior Concepts Related to Interactions within Environments** **PreK-K:** Living things are identified in a variety of ecosystems. Living things have physical traits, which enable them to live in different ecosystems. **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 plants, fruits, seeds, insects 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 unfavorable weather conditions 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, appropriate temperature range, light, water, air and nutrients. Changes in these conditions can affect the growing season for certain plants. The amount and distribution of these conditions will influence the types of plants that can survive in an area. Observations of seasonal changes in temperature, liquid water availability, wind and light are 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 as the environment changes. **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

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Environmental explorations			
Design an ideal habitat for a human. Identify ways human needs (e.g., water, shelter, air, space, food) are met by the habitat. Make drawings, descriptions or models of the habitat.	Go on an outside habitat exploration. What is in the habitat that meets the needs of both plants and animals? Make sure to include water sources and food sources (including sunlight for plants). Look for signs of nesting, places for animals to hide and places for animals to raise their young. Repeat the observations throughout different seasons and make comparisons. Visit different local or virtual habitats and compare the living things in the habitats. Multiple habitats could include one by a water source, a farm and/or the school ground. If possible, visit multiple times a year.	Create a graphic comparing the living things found in various habitats and during different seasons. Identify what habitat components humans need to survive. Compare different habitats and choose the best habitat for humans to survive in.	Explain how habitats meet the needs of a variety of plants and animals. Explain what an animal needs to survive in its habitat. Explain how seasons affect plants and animals. Explain how senses help humans survive in their habitat.
Plant investigations			
	Design investigations to discover what a plant needs to grow and survive. Change only one variable per plant group. Compare plants in the sun and plants in the dark; compare plants that are watered and ones that are not; compare seeds in soil and seeds that are not.	For the plant investigations, create a poster or journal entry demonstrating the differences in the plant growth.	Explain what a plant needs to survive in its habitat.

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 natural world around them in greater depth by using scientific inquiry.

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 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** This topic focuses on observing the relationship between forces and motion.	**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.
CONDENSED CONTENT STATEMENTS		
2.ESS.1: The atmosphere is primarily made up of air. **2.ESS.2:** Water is present in the atmosphere. **2.ESS.3:** Long- and short-term weather changes occur due to changes in energy.	**2.PS.1:** Forces change the motion of an object.	**2.LS.1:** Living things cause changes on Earth. **2.LS.2:** All organisms alive today result from their ancestors, some of which may be extinct. Not all kinds of organisms that lived in the past are represented by living organisms today.

NATURE OF SCIENCE GRADES K-2

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	K-2
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Apply knowledge of science content to real-world challenges. • Plan and conduct simple scientific investigations using appropriate safety techniques based on explorations, observations and questions. • Employ simple equipment and tools to gather data and extend the senses. • Use data and mathematical thinking to construct reasonable explanations. • Communicate with others about investigations and data.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past, and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• The world is discovered through exploration. • Exploration leads to observation. Observation leads to questions. • Natural events happen today as they happened in the past. • Events happen in regular patterns and cycles in the natural world.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Everyone explores the world which generates questions. • The answer is not always as important as the process. • Questions often lead to other questions. • Discoveries are communicated and discussed with others. • People address questions through collaboration with peers and continued exploration. • Everyone can see themselves as scientists.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• It is essential to learn how to identify credible scientific evidence. • Ideas are revised based on new, credible scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Complete *Nature of Science* document is found on pages 8-12.

Grade 2 continued

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	CONTENT ELABORATION
2.ESS.1: The atmosphere is primarily 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.	**Prior Concepts Related to Air and Atmosphere** **PreK-1:** The term energy is introduced in grade 1. Wind is air in motion. 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 is measured with a numeric value and direction (e.g., wind speed is 6 mph, wind direction is west to east). Air takes up space (volume) and has mass (differentiating between mass and weight is not necessary at this grade level). 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 are 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. **Future Application of Concepts** **Grades 3-5:** Renewable energy and air pollution are studied. Wind can weather and erode Earth's surface. **Grades 6-8:** Thermal energy transfers in the atmosphere, causing air currents and global climate patterns.

EXPECTATIONS FOR LEARNING

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Create an instrument to measure wind			
Design and construct an instrument that can measure wind speed and wind direction. Properties of the chosen materials and design should be evaluated as part of the testing and decision-making process. Demonstrate the final product to the class.	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 wind patterns (e.g., when the wind comes from the south the speed is lower than when the wind comes from the north).		Explain how an anemometer measures wind speed.
Air activities			
Design and construct a way to lift an object using air (e.g., plastic bags and straws). Journal or use technology to document the design trials and results.		Create a demonstration to show that air has mass and takes up space (has volume).	Describe the properties of air.

Grade 2 continued

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	CONTENT ELABORATION
2.ESS.2: Water is present in the atmosphere. Water is present in the atmosphere as water vapor. When water vapor in the atmosphere cools, it forms clouds, fog, rain, ice, snow, sleet or hail. **Note**: *The emphasis at this grade level is investigating condensation and evaporation, not memorizing the water cycle itself.* **Note**: *The emphasis is not in naming cloud types, but in relating the characteristics of the clouds with weather.*	**Prior Concepts Related to Water in the Atmosphere** **PreK-1:** The term energy is introduced in grade 1. Wind and water are observable parts of weather. Sunlight warms water and air. 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 focus is on investigation and understanding, not on vocabulary. Water can change from liquid to vapor and from vapor to liquid. When water in the atmosphere cools because of a change in energy, it often forms small droplets of liquid water or ice that can be seen as clouds. The small water droplets can then form raindrops. Water droplets can change to solid by freezing into snow, sleet or hail. Cloud formation and types of clouds are introduced as they relate to weather. Clouds are moved by wind. Factors such as water contamination/pollution can be introduced within this content statement as they relate 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 can be used to observe, share results or document data. Relating the required conditions to actual weather observations, collecting and documenting data, drawing conclusions from the data and discussions about the findings are 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 among the atmosphere, hydrosphere and lithosphere and biogeochemical cycles are studied.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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Designing technological/engineering solutions using science concepts	**Demonstrating science knowledge**	**Interpreting and communicating science concepts**	**Recalling accurate science**
Condensation and evaporation			
Design a device to collect water from the atmosphere (i.e. collect condensation).	Plan and implement an investigation to explore the factors that contribute to water evaporating into the atmosphere. Generate a list of all the methods that were tested and discuss the different results with the class. Plan and implement an investigation to explore 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.
Clouds			
	Document observations over a period of time to find if there is a relationship between the characteristics of the clouds (e.g., shapes, sizes, color, sky coverage) and the weather (e.g., storms, precipitation types and/or amounts).		List the various forms of water that can be found in the atmosphere (e.g., clouds, steam, fog, snow, sleet, hail).

Grade 2 continued

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	CONTENT ELABORATION
2.ESS.3: Long- and short-term weather changes occur due to changes in energy. Changes in energy affect all aspects of weather, including temperature, precipitation, and wind.	**Prior Concepts Related to Water in the Atmosphere** **PreK-1:** The term energy is introduced in grade 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 (from sunlight) and cooling of water, air and land are directly related to wind, evaporation, condensation, freezing, thawing and precipitation. Density and convection should not be introduced at this grade level. 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 can 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) are used to demonstrate the connection between weather and energy. Discussion of energy at this grade level should be limited to observable changes. **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 among the hydrosphere, lithosphere, and atmosphere are studied.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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Designing technological/engineering solutions using science concepts	**Demonstrating science knowledge**	**Interpreting and communicating science concepts**	**Recalling accurate science**
Weather			
Use wind-chill data to develop a school-wide recess policy based on wind-chill limits.	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. 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.	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. 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.	Recognize that a weather front is an area where different air masses collide. Recall that weather changes occur due to energy changes.

Grade 2 continued

PHYSICAL SCIENCE (PS)

Topic: Changes in Motion
This topic focuses on observing the relationship between forces and motion.

CONTENT STATEMENT	CONTENT ELABORATION
2.PS.1: 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.	**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 of an object by speeding up, slowing down, stopping or changing direction. Some forces act when an object is in contact with another object (e.g., physically pushing or pulling). Other forces act when objects are not in contact with each other (e.g., magnetic, gravitational, electrical). Gravitational, static electrical and magnetic forces are introduced through observation and experimentation only. The definitions of these forces should not be the focus of instruction. 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 can be explored through experimentation, testing and investigation at this grade level. For a particular object, larger forces 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 are used for this concept. 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 difference between force and energy will be developed over time and is not appropriate at this grade level. **Note***: Introducing fields, protons, electrons or mathematical manipulations of positive and negative to explain observed phenomena is not appropriate at this grade level.* **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.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Forces and motion			
	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 force). Recognize that greater changes in the motion of an object require larger forces.
Gravity			
	Explore the effects some very massive objects have on others even when the two objects might not touch (e.g., explore falling objects). Identify Earth as the object exerting the force of gravity on the falling objects.		Illustrate the effects of gravity through writing or pictures.
Magnets: pulling			
Design and construct a device to move an item from one position to another without touching (e.g., a metal matchbox car and magnet). Test the device and evaluate the design. If necessary, redesign the device until it can accomplish the task.	Explore the effects some objects have on others even when the two objects might not touch (e.g., experiment with different types and strength of magnets). Determine ways to vary the motion of the objects.	Pictorially represent the design of the device designed to move an object from one position to another without touching. Compare class designs and their effectiveness.	Identify a noncontact force that can affect the motion of an object (e.g., magnetic force, static electrical force, gravitational force).

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Magnets: poles			
Use the polarity of a magnet to accomplish a task. Use magnets to create a game.	Explore a variety of magnets to discover poles (e.g., create floating rings with donut magnets and a pencil, observe the interaction of two bar magnets, use iron filings around various magnets).		Through writing and/or pictures represent orientations of magnets that will attract (pull) and repel (push).
Static electricity			
	Explore the effects charged objects can have on other objects even when the two objects might not touch (e.g., experiment with a balloon rubbed on hair and pieces of paper).		
Seat belts			
Design a seat belt to protect dogs or other service animals when in a car.	Design an investigation using a large toy car, ramp, doll and tape to represent how seat belts provide protection in a moving car.	Write a letter to a local government official persuading them to recommend laws to keep pets safe in cars based on seatbelt data from an investigation.	Explain how the size of a force can impact motion.
Amusement rides			
Design and construct an amusement park ride that will keep a rider safe while speeding up, slowing down, changing direction and/or stopping.	Explore ways to change how something is moving (e.g., speeding up, slowing down, changing direction, stopping).	Draw an amusement ride. Label where the ride speeds up, slows down or changes direction.	Give two examples of how a force is applied in an amusement ride.

Grade 2 continued

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	CONTENT ELABORATION
2.LS.1: 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.*	**Prior Concepts Related to Interactions within Environments** **PreK-1:** Macroscopic characteristics of living things are observed, 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 ecosystems, which can be observed. These interactions can cause changes in groups of living things and the physical environment (e.g., soil, rocks, water). Conducting investigations (in nature or virtually) to document specific changes in the ecosystem, as well as the results of those changes, are 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 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 are investigated and explored. The focus is not limited to human interaction with the environment (such as resource use or recycling) and includes activities such as observing earthworm compost bins, ant farms and weeds growing on vacant lots. **Future Application of Concepts** **Grades 3-5:** Changes that occur in an ecosystem can sometimes be beneficial and sometimes harmful. **Grades 6-8:** Matter is transferred constantly from one organism to another and between organisms and their physical environment.

EXPECTATIONS FOR LEARNING

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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Designing technological/engineering solutions using science concepts	**Demonstrating science knowledge**	**Interpreting and communicating science concepts**	**Recalling accurate science**
2.LS.1: Living things cause changes on Earth			
Design and build (with teacher help) a working worm composting bin or ant farm (whichever is most appropriate for the classroom) that can be used to observe the actions of the worms or ants. The project selected should be built on student ideas and 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. **Note:** *For this grade level, the presence of bacteria and fungi in soil 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.*	Take a nature walk around the school on a weekly basis to make observations of changes in the ecosystem. Document through pictures or drawings. Look for human impact versus nature (e.g., breaking up a sidewalk due to tree roots, weeds growing through the sidewalk or blacktop). 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 that compares them to soil samples without earthworms).	Recognize scientifically accurate facts in stories about environmental changes caused by living things. Identify ways humans have changed the Earth to provide food and energy for our bodies (e.g. farming, mining, creating dams).

Grade 2 continued

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	CONTENT ELABORATION
2.LS.2: All organisms alive today result from their ancestors, some of which may be extinct. Not all kinds of organisms that lived in the past are represented by living organisms today. Some kinds of organisms become extinct when their basic needs are no longer met or the environment changes.	**Prior Concepts Related to Interactions within Environments** **PreK-1:** Living things have physical traits, which enable them to live in different ecosystems. **Grade 2 Concepts** Fossils are preserved physical traces of past living things (e.g., shells, bones, leaves, tracks, imprints, eggs, scat). 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 individual of a kind of organism. Extinction generally occurs as a result of changed conditions where the basic needs are not met. Some kinds of living things that once lived on Earth have completely disappeared (e.g., saber-tooth cat, trilobite, mastodon). Plants and animals alive today resemble organisms that once lived on Earth (e.g., ferns, sharks). **Future Application of Concepts** **Grade 3-5:** Fossils are addressed in more detail. **Grades 6-8:** This concept is expanded to provide a partial explanation of biodiversity.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
	Fossils		
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 (e.g., 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? Explore fossils and decide whether they came from a plant or animal. Compare the fossilized organisms to living organisms. Record similarities and differences and make inferences about relationships between the past and present.	Use a graphic organizer to compare the macroscopic features of organisms that are alive today (e.g., an elephant) with those of similar extinct organisms (e.g., a mammoth). Further examples include saber-tooth cats and house cats, mosasaurs and lizards, trilobites and insects and rugose coral and brain coral.	
	Extinction		
		Research extinct animals and discuss changes to their ecosystems that may have led to their extinction.	Discuss what factors can cause a plant or animal to become extinct. Name an organism that was once abundant in the local area that now is extinct or endangered.

Grade 3

INTRODUCTION TO CONTENT STATEMENTS

GRADE BAND THEME: INTERCONNECTIONS WITHIN SYSTEMS

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

STRANDS

Strand Connections: Matter is what makes up all living and nonliving 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 for materials and energy. 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 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.	**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.	**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.
CONDENSED CONTENT STATEMENTS		
3.ESS.1: Earth's nonliving resources have specific properties. **3.ESS.2:** Earth's resources can be used for energy. **3.ESS.3:** Some of Earth's resources are limited.	**3.PS.1:** All objects and substances in the natural world are composed of matter. **3.PS.2:** Matter exists in different states, each of which has different properties. **3.PS.3:** Heat, electrical energy, light, sound and magnetic energy are forms of energy.	**3.LS.1:** Offspring resemble their parents and each other. **3.LS.2:** Individuals of the same kind of organism differ in their inherited traits. These differences give some individuals an advantage in surviving and/or reproducing. **3.LS.3:** Plants and animals have life cycles that are part of their adaptations for survival in their natural environments.

NATURE OF SCIENCE GRADES 3-5

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	3-5
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Observe and ask questions about the world that can be answered through scientific investigations. • Design and conduct scientific investigations using appropriate safety techniques. • Use appropriate mathematics, tools, and techniques to gather data and information. • Develop and communicate descriptions, models, explanations and predictions. • Think critically and ask questions about the observations and explanations of others. • Communicate scientific procedures and explanations. • Apply knowledge of science content to real-world challenges.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• Science is both a body of knowledge and processes to discover new knowledge. • Science is a way of knowing about the world around us based on evidence from experimentation and observations. • Science assumes that objects and events occur in consistent patterns that are understandable through measurement and observation.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• People from many generations and nations contribute to science knowledge. • People of all cultures, genders, and backgrounds can pursue a career in science. • Scientists often work in teams. • Science affects everyday life. • Science requires creativity and imagination.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science develops theories based on a body of scientific evidence. • Science explanations can change based on new scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Complete *Nature of Science* document is found on pages 8-12.

Grade 3 continued

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

3.ESS.1: 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. Use the term "soil", not "dirt". Dirt and soils are not synonymous.

Rocks have specific characteristics that allow them to be sorted and compared. Rocks form in different ways. Air and water are also nonliving resources.

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

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 are 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, as well as, texture and color or the rock. Age-appropriate tools are 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.

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

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
		Rocks	
Design a rock garden.[1]	Investigate which rocks would be best to use for building a rock garden.	Choose a famous rock feature (e.g., Grand Canyon, Uluru, Giant's Causeway) and research information on the rock type, special features and formation history. Determine what rock types would be best for creating statues, monuments or carvings like Mount Rushmore.	Identify rock, soil, air and water as examples of non-living resources. Explain that rocks form in different ways and that air and water play an important role in the formation of rocks. Organize different types of rocks[2] by characteristics such as grain size, texture, layering, color or patterns. Graphically represent and clarify the sorted results.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Comparing soils			
Design and create a school garden by testing the soil in an area and determining what plants will grow best in the area.	Design an investigation to compare two soil samples to determine differences in their color, texture, capacity to retain water and air and ability to support plant growth.		Correlate characteristics of soil (e.g., grain size) to soil drainage and the ability to support plant life. Match soil types with appropriate applications (e.g., building structures, supporting plant life, solving erosion issues). Recognize that soil can have different texture, composition or color depending on the environment in which it formed.
School yard soil solutions			
Identify an issue around the school yard involving poor water drainage. Based on previous investigations for soil types, determine possible solutions for the pooling water. Evaluate solutions to determine the most appropriate. Design a sustainable landscape[3] or wildlife garden for people and wildlife to enjoy.	Investigate a variety of soil types to determine drainage rates. 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 fastest/farthest? What properties of soil contribute to these observations?	Write a letter to the school board explaining a drainage problem in the school yard and describing how the proposed solution will address the issue.	Show that some soil types are able to absorb water while other soil types allow water to pass through.

[1] Rock Garden
[2] Types of Rocks
[3] Sustainable Landscapes

Grade 3 continued

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	CONTENT ELABORATION
3.ESS.2: Earth's resources can be used for energy. Renewable energy resources, such as wind, water or solar energy, can be replenished within a short amount of time by natural processes. Nonrenewable energy is a finite resource, such as natural gas, coal or oil, which cannot be replenished in a short amount of time.	**Prior Concepts Related to Energy from Earth's Resources** **PreK-2:** Wind is air in motion. Water and wind have measurable properties. 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 circuits 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 can be compared to other states regarding energy sources. **Future Application of Concepts** **Grades 4-5:** Energy is explored through electrical energy, magnetic energy, thermal energy, 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

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Renewable and nonrenewable energy			
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. Recommend a type of energy for a new community[1] for Ohio. Design a device that utilizes renewable energy (e.g., solar oven, wind turbine, dam) and explain how energy is being transferred and used.	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 how different forms of clean energy work and explain the process using words or pictures. Use data[1] about consumption, emissions, and usage to compare different types of renewable and nonrenewable energy. Create a media presentation showing the differences between renewable and nonrenewable resources. Provide examples of each.	Sort energy types (e.g., cards with words or pictures) based on whether the energy source is renewable or nonrenewable. Explain commonalities and differences in energy types. Recognize the difference between renewable and nonrenewable energy. Be able to provide examples of each.
Local energy			
Propose a plan that addresses an issue that affects school's energy use or home energy use (e.g., expense, high emissions, power outages, switching to clean energy).	Investigate incandescent and fluorescent bulbs for light and heat emissions[2]. Compare results.	Research the source of energy for school or home. Write a persuasive essay (e.g., to a parent, principal, superintendent) about what energy type is being used and suggestions for more efficient use.	Identify whether the source(s) of local energy are renewable or nonrenewable.

[1]Energy for a New Community
[2]Incandescent and Fluorescent Bulbs

Grade 3 continued

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	CONTENT ELABORATION
3.ESS.3: 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.	**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 is 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 studied. **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 explored.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
		Water conservation	
Design and propose a plan to conserve water or reduce water pollution. If possible, use a water issue specific to your area. Investigate a way that pollution is affecting the environment (e.g., impact of an oil spill on animals, fertilizer pollution in ponds, groundwater pollution). Provide possible solutions to reduce the negative impacts.		Research the ways water gets polluted and report findings. Depending upon your school's watershed, investigate types of pollution impacting the Ohio River or Lake Erie. Create a persuasive essay discussing pollution impacting the local watershed and ideas about ways to reduce the pollution. Create commercials about ways to conserve water in your everyday life.	
		Reuse and repurpose	
Conduct a repurpose challenge by designing new uses for trash or throw away items. Redesign a consumer product (e.g., ice cream container, snack bag) so that it results in less material being thrown away.	Create a model landfill (e.g., plastic box with dirt, water and various organic and inorganic consumer products). Observe it over the course of the year, recording changes to the various materials. Identify the types of materials which biodegrade and those that do not.	Research how long it takes common waste materials to biodegrade. Report findings and describe the possible impacts of various materials on the environment 5, 10 or 50 years in the future.	Identify the materials found in common items (e.g., aluminum cans, paper, pencils, plastic water bottles).

Grade 3 continued

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	CONTENT ELABORATION
3.PS.1: All objects and substances in the natural world are composed of matter. Matter takes up space and has mass. Differentiating between mass and weight is not necessary at this grade level.	**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. **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. The atomic and subatomic nature of matter is not appropriate at this grade level. Mass is defined as a measure of how much matter is in an object. The more matter there is in an object, the greater the mass. Volume is a measure of the amount of space an object occupies. Provide opportunities to investigate and experiment with different methods of measuring mass and liquid volume using the metric system and nontraditional units (e.g., nails, paper clips). 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. **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.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Properties of matter			
Design a method or device to keep a chocolate bar from melting in a hot car.		Design a simple demonstration that will show that air is made of matter. 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.	Explain that water continues to exist after it evaporates.
Mass and volume			
Design a backpack with appropriate pockets/sections that has the largest volume but the least mass. Mass and volume measurements can be in nonstandard units.	Make observations of a material that absorbs water (e.g., water beads, magic grow animals, diapers). Measure the mass of the materials and volume of water absorbed over time. Graph and identify patterns in their growth rate.	Measure and compare the masses of two different materials that have the same volume (e.g., piece of foam and equal-sized piece of wood).	Measure the mass of an object using standard and nonstandard units. Measure the volume of an object using standard and nonstandard units.

Grade 3 continued

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	CONTENT ELABORATION
3.PS.2: Matter exists in different states, each of which has different properties. The most recognizable 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.	**Prior Concepts Related to Matter** **PreK-2:** Materials can be sorted by properties. The physical properties of water change as observed in weather. **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 they occupy (retaining their volume). Gases assume the shape and volume of their containers. Only solids, liquids and gases are appropriate at this grade level, even though other phases have been identified. Heating may cause a solid to melt to form a liquid or cause a liquid to boil or evaporate to form a gas. The differences between boiling and evaporation are not appropriate at this grade level. 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), can be used to reinforce the concept that materials other than water also go through phase changes. **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.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
States of matter			
	Investigate frozen water balloons and the various conditions that affect the rate at which the ice melts. Determine which material (e.g., sand, salt, calcium chloride) melts ice the fastest. Design and conduct an investigation to determine which liquid/substance will freeze fastest. Make predictions, then graph and present conclusions.	Melt a variety of substances (e.g., candle, chocolate bar, butter, bacon grease) and compare the temperatures at which they melt.	Categorize a variety of materials at room temperature as solids, liquids or gases. Construct a snowman and observe over time. Identify the phase changes of water that occur.

Grade 3 continued

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

3.PS.3: 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. The different forms of energy that are outlined at this grade level should be limited to familiar forms 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. Weather changes occur due to changes in energy. Living things require energy. Plants get energy from sunlight.

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 liquid 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) are used to demonstrate the relationship between different forms of energy and motion. 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. 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. 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 not appropriate 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.

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.

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Energy			
Design a more effective box for pizza that will keep it warm and be eco-friendly. Design, construct and test a small boat or aircraft that can move in different directions or against the flow of water/air. Document the forms of energy involved and the resulting motion.	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).	Compare the motion of a drop of food coloring in various temperatures of water. Explain ways 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.	Recognize that energy can cause motion or create change. Identify objects with energy in the environment (e.g., moving water, windmill, water wheel, sunlight) and determine what types of energy they have.

Grade 3 continued

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	CONTENT ELABORATION
3.LS.1: 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.	**Prior Concepts Related to Behavior, Growth and Changes** **PreK-2:** Similarities and differences exist among individuals of the same kind of plant or animal. **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 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 (e.g., food, shelter) from the environment and this 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 behavioral traits 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 necessary. 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. **Note:** *Human genetic study is not recommended since not all students may have information available from their biological parents.* **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 how new cells get the genetic information of the old cells. The genetic details of reproduction will be outlined.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Offspring resemble their parents			
	Make comparisons between a plant and its offspring. Harvest the seeds from a plant (e.g., fast growing plant, bean) or use cuttings. Grow the seeds or cuttings and compare the offspring to the original plant (e.g., actual plant, photos, preserved specimens). Conduct a real-time observational study of a familial grouping of organisms. Use webcams to view animals in their natural or simulated habitat to observe and record physical characteristics of the animals. Falcon cams are used by the Ohio Department of Natural Resources and can be used for this study.	Based on data from observational studies of offspring and their parents, develop a chart that compares features (e.g., stages of development, food sources, where they are found in the habitat, physical appearance) to emphasize the similarities and differences. Make a chart to identify physical traits that differ among humans and those that are the same for all.	Use pictures of animal parents and babies to demonstrate similarities and differences. Match animal babies to their parents. Using pictures of many different people, from different periods and places in the world throughout human history, identify features all humans have that stay the same from generation to generation. Explain that all humans have hearts, skin, stomachs, lungs, bones, eyes and other organs.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Wildlife watching			
Redesign the schoolyard to make it better for wildlife. Make wildlife observations around the school yard. Identify how observed behaviors are related to survival (e.g., food, water, shelter). Identify ways to attract more wildlife to the school yard.	Conduct a real-time observational study of plants and animals around the school, a park, or a nature center over the course of a season or year. Make observations of which plants and animals are present and wildlife behaviors. Compare one habitat to another (e.g., the school yard to the park) for similarities and differences in plant and animal life and behavior.	Create graphs or charts to share data collected from a wildlife observational study. Identify patterns in the data and show how observed behaviors (plant and animal) help the organisms survive.	Observe a group of the same type of wildlife (e.g., apples, dandelions, worms, squirrels, cardinals, blue jays) to identify variation within the species (e.g., different sizes, coloring).
Animals			
Identify ways that humans can assist animals by providing resources that are lacking in the environment due to human impacts or natural environmental changes (e.g., building bat houses, bird feeders). Choose an example to design and construct. Monitor its use.		Investigate various types of learned and inherited behaviors in an animal and create a pamphlet describing the behaviors. Investigate how human activity is changing animals' behaviors (e.g., animals being fed, leaving trash outside in cans) and summarize findings. Make real-time observations of animals (e.g., in the schoolyard, webcams, trail cameras, videos) and identify which behaviors are instinctive, which are learned, and which are a response to the environment. Include evidence to support the identification.	Identify structures that are built by animals (e.g., nests, dams) and the purpose they serve for the animal.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
		Plants	
	Plant multiple seeds in a clear container, each oriented in a different direction. Observe the direction of root and stem growth. Test additional types of seeds to see if there is a general behavior pattern for plants.	Based on plant behavior investigations write a short report using the data collected to explain observations.	Give examples of variations among individuals of a local population of dandelions (e.g., height, color, weight). Match plant behaviors with their causes (e.g., bending toward the light, shedding leaves, wilting).

Grade 3 continued

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

3.LS.2: Individuals of the same kind of organism differ in their inherited traits. These differences give some individuals an advantage in surviving and/or 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 influence their chances of surviving in particular environments.

Note: *The focus is on the individual, not the population. Adaptation 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 and 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 survive 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 their features (traits) on to their offspring and future generations. Some grade-appropriate organisms to study are plants (e.g., radishes, beans) and animals (e.g., butterflies, moths, beetles, brine shrimp).

Comparisons can be made in nature or virtually. Tables and diagrams (e.g., Venn) 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

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Plant investigation			
Make observations in a community garden or school yard and identify growing conditions that may be lacking (e.g., access to water, soil, sunlight). Develop a solution to the problem (e.g., irrigation system, raised beds, planting additional plants). A soil and water district representative or agricultural extension agent can assist in this process.	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. Investigate the variations of each plant feature studied.	Using data from the comparative plant study organize results to see differences in the physical features of the same type plants.	Identify similarities and differences between various native plants.
Plants			
Investigate a variety of greenhouse and terrarium designs. Decide what type of structure would be the right fit for your classroom or schoolyard and design a model.		Investigate the movement of colored water in celery to demonstrate the function of the stem and interpret how the food coloring travels to the leafy celery top. Have some celery stalks "stalks down" and others "leaves down" to investigate whether the food coloring moves in both directions. It is not important to know the term "xylem", but rather to understand that water is absorbed through the roots and transported through the stems to provide water to the rest of the plant.	Identify some plants from different environments for comparisons (e.g. cacti, pine trees, deciduous trees, prairie grass, swamp wildflowers, forest wildflowers). Explore why some plants may not be found in the school yard (e.g., cacti, swamp-loving plants) to understand the relationship between habitat and plant type.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Animals			
In the process of planning an investigation to study the life cycle of a butterfly, evaluate the design of three emergence cages.[1] 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.	Investigate the pill bug and the bug's behaviors (e.g., light/dark, wet/dry, soil/sand) and compare resulting behavior with their natural habitat.	Research how the traits of polar bears allow them to survive in the Arctic habitat. Identify how these traits are impacting the polar bears in a changing habitat. Describe how inherited human traits can help in survival (e.g., how the shape of teeth helps in the consumption of food, why walking upright is beneficial). Research inherited human traits that can vary. Predict whether these traits provide a survival advantage, disadvantage or have no effect.	Provide a habitat and identify an animal that would thrive in that habitat.

Grade 3 continued

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

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

Worldwide, 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.*

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 ecosystem. 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 ecosystems (e.g., trees lose their leaves in the winter to conserve water). Most life cycles start with birth, budding or germination, 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 lenses, 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 for review.

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

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Designing technological/engineering solutions using science concepts	**Demonstrating science knowledge**	**Interpreting and communicating science concepts**	**Recalling accurate science**
Animal life cycles			
Use knowledge about a species' lifecycle and needs to design an enclosure for that species.	Plan an investigation to study the lifecycle of a species (e.g., butterfly, moth, darkling beetle, brine shrimp, worm, mealworm, chicken). Make observations and think about animal needs at different stages of the life cycle. Note changes in physical appearance and body parts.	Compare the life cycles of two species. Identify differences and share findings in a presentation. Compare different stages of the human life cycle (e.g., infant, toddler, child, adolescent, young adult, older adult). Identify physical and behavioral features.	Given photographs of stages of a variety of animal life cycles, place them in sequence from egg or infant to adult.
Plant life cycles			
	Design an investigation to find out the optimal conditions for seed germination.	Compare the life cycles of different plants noting similarities and differences. Include the time each stage takes, what it looks like and where each plant might be found.	Choose a plant and create a life cycle diagram for that plant.

Grade 4

INTRODUCTION TO CONTENT STATEMENTS

GRADE BAND THEME: INTERCONNECTIONS WITHIN SYSTEMS

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

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 This topic focuses on the variety of processes that shape and reshape Earth's surface.	**Topic: Electricity, Heat and Matter** 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	**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.
CONDENSED CONTENT STATEMENTS		
4.ESS.1: Earth's surface has specific characteristics and landforms that can be identified. **4.ESS.2:** The surface of Earth changes due to weathering. **4.ESS.3:** The surface of Earth changes due to erosion and deposition.	**4.PS.1:** When objects break into smaller pieces, dissolve, or change state, the total amount of matter is conserved. **4.PS.2:** Energy can be transferred from one location to another or can be transformed from one form to another.	**4.LS.1:** Changes in an organism's environment are sometimes beneficial to its survival and sometimes harmful. **4.LS.2:** Fossils can be compared to one another and to present-day organisms according to their similarities and differences.

NATURE OF SCIENCE GRADES 3-5

Nature of Science One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.	
Categories	**3-5**
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Observe and ask questions about the world that can be answered through scientific investigations. • Design and conduct scientific investigations using appropriate safety techniques. • Use appropriate mathematics, tools, and techniques to gather data and information. • Develop and communicate descriptions, models, explanations, and predictions. • Think critically and ask questions about the observations and explanations of others. • Communicate scientific procedures and explanations. • Apply knowledge of science content to real-world challenges.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• Science is both a body of knowledge and processes to discover new knowledge. • Science is a way of knowing about the world around us based on evidence from experimentation and observations. • Science assumes that objects and events occur in consistent patterns that are understandable through measurement and observation.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• People from many generations and nations contribute to science knowledge. • People of all cultures, genders, and backgrounds can pursue a career in science. • Scientists often work in teams. • Science affects everyday life. • Science requires creativity and imagination.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science develops theories based on a body of scientific evidence. • Science explanations can change based on new scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Complete *Nature of Science* document is found on pages 8-12.

Grade 4 continued

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	CONTENT ELABORATION
4.ESS.1: 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, groundwater and glaciers. 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.	**Prior Concepts Related to Surface of Earth** **PreK-2:** Wind and precipitation can be measured. Water can change state. Heating and cooling can change the properties of materials. 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 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 occur to the resulting landform, feature or characteristic is 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. **Grades 6-8:** Global seasonal changes are introduced, including monsoons and rainy seasons, which can change erosion and deposition patterns. 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 erosion and deposition related to oceans.

EXPECTATIONS FOR LEARNING

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This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Water on Earth exploration			
	Investigate the amount and types (e.g., saltwater, frozen water, freshwater) of water that cover Earth's surface. Create a grid on actual maps of Earth, or regions of Earth, to determine the portion that is covered in water. Determine the amount of fresh and salt water.	Create a visual representation of where water exists on Earth (e.g., oceans, streams and rivers, glaciers and ice caps, groundwater, lakes, atmosphere, plants and animals). Create a model (e.g., virtual, graphic, or 3-D) of a type of body of water including the landforms that surround it.	Explain why Earth is known as the Blue Planet.
Erosion and deposition			
	Use a model of a landform to investigate erosion. Create a 3-D model of a landform in a waterproof tub or container using natural materials such as dirt, sand and grass. Pour water over the model to investigate how water moves and settles around the landform. Design a model of glacial movement over land and use it to observe, measure and record evidence of the effects of the glacier on the land. Take time-lapse photos, if possible, of the glacier models and compare them with photos of real-life landscape changes due to the effects of glaciers.	Explain how a landscape is affected by glacial movement, how the environment would be affected by such changes, how a glacier would impact various soil types, and how rising temperatures might affect the rate of glacial movement and change.	Identify the processes that can change the surface of Earth (e.g., erosion, deposition, volcanic activity, earthquakes, glacial movement, weathering). Identify landforms or features using maps and photographs.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Catastrophic events			
Investigate catastrophic events that have changed Earth's surface (e.g., landslides, flash flooding, volcanoes, earthquakes), design and propose a plan to reduce negative effects on humans and/or the ecosystem.		Research a specific landform of interest (e.g., Cape Cod, Mt. St. Helens, Mississippi River, Rocky Mountains, Hawaiian Islands, Grand Canyon, Mississippi Delta, Hood Canal, Mendenhall Glacier). Explain how the landform was formed and has changed over the years. Include any catastrophic events that may have changed it, as well as any cultural or historical events that have taken place there.	
Landforms			
Use information about landforms to plan an efficient route for a highway, location for a ski lodge, location for a state park, amusement park, etc. using a topographic map and other resources. Consider the location of landforms (e.g., mountains, hills, rivers, plains) and how the landforms impact the location and design.		Explain the similarities and differences of a variety of landforms. Discuss the ways each landform was formed. Create a relief or topographic map of a neighborhood or region. Research different landforms and map features that are in the area. Use blackline maps of the area and color in different landforms. Create a key for the map, to show the different heights and depths of landforms (e.g., hills, mountains, canyons, chasms) by using different patterns or colors.	Identify common landforms from maps or graphics (e.g., streams, deltas, floodplains, hills, mountains/mountain ranges, valleys, sinkholes, caves, canyons, glacial features, dunes, springs, volcanoes, islands).

Grade 4 continued

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	CONTENT ELABORATION
4.ESS.2: The surface of Earth changes due to weathering. Rocks change shape, size and/or form due to water or glacial movement, freeze and thaw, wind, plant growth, acid rain, pollution and catastrophic events such as earthquakes, flooding, and volcanic activity. **Note:** *Differentiating between chemical and physical weathering is not the focus at this grade level.*	**Prior Concepts Related to Weathering** **PreK-2:** Wind is air in motion. Water and wind have measurable properties. Water changes state. Properties of materials change when exposed to various conditions (e.g., heating, cooling). 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 is 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. **Grades 6-8:** 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. 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. The causes of changes on Earth's surface are investigated.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
	Weathering		
Using the connection between weathering and changes to the surface of the Earth, write and present a proposal for the building of a stationary object (e.g., statue, patio, staircase) utilizing materials that are resistant to weathering.	Use a weak acid (e.g., vinegar, soda, lemon juice) to investigate the effects of acid rain on various types of rocks or structures. Design an investigation of the freeze-thaw cycle and how this process breaks down rock and wood over time (e.g., a temperature-effect simulation). Relate this to the action of water, rain and snow which enters the crevices of rock, pavement, concrete or wood, freezing and expanding the materials, eventually breaking them down into smaller pieces.	Create a visual representation of the signs of weathering in a local city or town. Indicate the causes of weathering for each occurrence.	Discuss how potholes form. Recognize that water, wind, pollution/ gases in the air, ice movement, earthquakes, volcanoes, freezing/thawing and plant action can all weather rock and soil.

Grade 4 continued

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	CONTENT ELABORATION
4.ESS.3: The surface of Earth changes due to erosion and deposition. Liquid water, wind and ice physically remove and carry rock, soil and sediment (erosion) and deposit the material in a new location (deposition). Gravitational force affects movements of water, rock and soil.	**Prior Concepts Related to Erosion and Deposition** **PreK-2:** Wind is air in motion. Water and wind have measurable properties. Water changes state. Forces change the motion of an object. 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 movement (e.g., mudslides, avalanches, landslides) or flooding. Erosion is a "destructive" process and deposition is a "constructive" process. Erosion and deposition directly contribute to formation of the landforms and features 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** **Grades 6-8:** Historical studies of erosional and depositional patterns, soil conservation, the interaction of Earth's spheres, ocean features specific to erosion and deposition, and plate tectonics are introduced. Global seasonal changes including monsoons and rainy seasons, which can change erosion and deposition patterns, are also introduced.

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Erosion			
Conduct a walking field trip around the school grounds or a local park. Investigate areas where there have been slow changes, (e.g., stream beds, steps, sidewalks, pavement). Design a solution to slow the rate of erosion (e.g., plant choices, fencing, wind barriers).	Design and conduct an experiment to compare the amount of erosion between soil with varying amounts of surface coverage (e.g., no coverage, rocks, dead leaves, growing plants). Use data to conclude how erosion is best minimized.	Use models, pictures or other visual representations to compare erosion and deposition. Cite the importance of erosion in the process of reshaping Earth's surface using specific real-world examples (e.g., Mississippi River).	Describe the different agents of erosion (e.g., wind, water, ice).
Deposition			
		Cite the importance of deposition in the process of reshaping Earth's surface using specific real-world examples (e.g., Mississippi River).	Describe the features created by deposition.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Connections among weathering, erosion, and deposition			
Simulate wind erosion and water erosion (e.g., use sand to build a mountain and then use a straw and/or watering can to erode it*)*. Make observations and relate the erosion processes to weathering and sediment deposition. Propose ways to slow the erosion. Design a model to show the erosion and deposition occurring with wave movement in coastal environments, taking into account the beach composition and atmospheric conditions. Experiment with a variety of materials and factors (e.g., plant life, coastline composition, slope) to determine which environment is the most stable for human activity. Design and test a solution to slow the rate of erosion for coastline preservation.	Investigate different farming or landscaping methods that slow erosion. Connect the method with the topography of the area. Describe why that method is appropriate for that area.	View images where erosion and deposition have occurred (e.g., waterfalls, sand dunes, rivers, glaciers, canyons). Determine the causes of the erosion and deposition and sort them accordingly. Describe how these processes are changing Earth's surface. Observe and compare places where roots can help prevent/slow erosion and places where roots cause erosion.	Write cause and effect statements that explain changes in Earth's surface from weathering, erosion, and deposition. Identify specific instances of erosion and deposition across an extended period of time through time lapse video. Describe how weathering, erosion and deposition work together as a continual process.

Grade 4 continued

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	CONTENT ELABORATION
4.PS.1: When objects break into smaller pieces, dissolve, or change state, the total amount of matter is conserved. 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:** *Differentiation between mass and weight is not necessary at this grade level.*	**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 mass and takes up space. Matter includes solids, liquids and gases (air). Phase changes are explored. Heating and cooling is one way to change the state of matter. **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 the mass of all 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 should be developed from experimental evidence collected in the classroom. After the concept has been well established with experimental data and evidence using closed systems (i.e., systems where matter cannot enter or leave the system), investigations can include interactions that are more complex where the mass may not appear to stay constant (e.g., fizzing tablets in water). 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.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Conservation of matter			
Relate the environmental impact of garbage (e.g., the Great Pacific Garbage Patch, Wailingding Island, China) to the fact that matter is conserved. Write a proposal to address the problems and develop a presentation that includes evidence from research.	Make and test hypotheses about what will happen to the total mass during many types of changes (e.g., change in size, change in shape, change in arrangement of pieces, mixtures, solutions, ice melting, salt dissolving, paper tearing, candle burning, Alka-Seltzer in water, Lego building blocks).	Investigate what happens to mass in a closed system when changes occur in the system (e.g., dissolve salt in water, fill a balloon with baking soda and add it to vinegar in a bottle keeping the seal tight around the top of the bottle). Compare the mass of the system before and after the change.	Explain that the amount of matter stays constant during any change. Use an inflated balloon, at room temperature and after being cooled in a freezer, to support the claim that the mass of a gas stays the same as temperature changes.

Grade 4 continued

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

4.PS.2: Energy can be transferred from one location to another or can be transformed from one form 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 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. 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

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). 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).

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 heat, thermal energy and radiant energy is not appropriate 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. Exploring heat transfer in terms of moving submicroscopic particles is not appropriate at this grade level.

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 is 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 are 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 transformed into light, sound, heat or magnetic energy. Electrical devices in a working circuit often get warmer.

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 can be explored in the laboratory through experimentation. 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.

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 investigated. Conservation of energy and energy transfer through radiation, convection and conduction are studied. The transfer of electrical energy in circuits is investigated further.

EXPECTATIONS FOR LEARNING

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Energy transfer			
Design and construct a device that accomplishes a task (e.g., causes a small cart to roll, pops a balloon, raises a flag, rings a bell) using a series of energy transfers between multiple objects (e.g., push a ball off a table so it falls on an object that releases a rubber band cart). Determine if energy would transfer to complete a system given a diagram of a possible energy transfer system (e.g., picture of a Rube Goldberg machine, mousetrap game). Explain why the system would or would not be successful. Explain what could be changed or altered to make the system more successful.	Investigate how changes to a simple electromagnet (e.g., more coils of wire, more batteries, different nails) affects the strength of its magnetic field (e.g., number of paper clips picked up, distance from which it can affect a paper clip).	Describe the energy transfers that occur between multiple objects in order for a device to accomplish a task (e.g., cause a small cart to roll, pop a balloon, raise a flag, ring a bell).	

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Simple circuits			
Design and construct a switch that can activate a device (e.g., lighting a bulb or LED, running a motor, sounding a buzzer)	Analyze the differences between working and nonworking (open and closed) circuits and determine patterns and trends in the experimental evidence. Formulate a conceptual model of a working circuit based upon the trends in the experimental evidence. Test a variety of materials in a complete circuit. Explore which materials are electrical conductors and which materials are electrical insulators. Use results to identify similarities in materials that are conductors or materials that are insulators.	Represent the flow of energy through a circuit in which a power source is used to activate a device (e.g., using pictures, models, diagrams).	Identify the functions (e.g., conductor, insulator, energy source) of the components of a simple electric circuit. Explain that a working circuit requires a continuous loop of electrical conductors and a source of energy. Identify different types of energy conversions within an electrical circuit. Label the parts of a circuit.
Heat energy			
Design an insulating device that will keep an object (e.g., ice cube, hot water, food) at a desired temperature. Collect and organize accurate data on the changes in temperature.	Investigate a variety of ways to heat food items (e.g., popcorn, hot dogs, marshmallows, chocolate, water). Collect and organize data on the changes in temperature. Evaluate the effectiveness of the heating methods.	Contrast thermal conductors and thermal insulators.	Measure the temperature of water. Recognize that an increase in temperature indicates an increase in thermal energy and a decrease in temperature indicates a decrease in thermal energy. Identify ways the temperature of an object can be changed (e.g., rubbing, heating, bending of metal). Explain in words and show in diagrams, pictures or models, the sources of thermal energy and the heat transfers that occur when heating a food item or a liquid.

Grade 4 continued

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	CONTENT ELABORATION
4.LS.1: 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. Ecosystems are based on interrelationships among and between biotic and abiotic factors. These include the diversity of other organisms present, the availability of food and other resources, and the physical attributes of the environment.	**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 ecosystem. 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 ecosystems. **Grade 4 Concepts** Ecosystems can change rapidly (e.g., volcanic activity, earthquakes, fire) or very slowly (e.g., climate change). Ohio has experienced various climate patterns. Glaciers covered parts of Ohio and other parts of Ohio were submerged with water as indicated by Ohio's fossil record. Major changes, both natural and human caused, over a short period of time can have significant impacts on ecosystems and populations of plants and animals. 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. Specific ecosystems in Ohio (e.g., rivers, streams, meadows, bogs, lakes, moraines, other natural areas) can be researched and investigated via field studies and virtual field trips. The relationships between current and past ecosystems, the changes that have occurred over time in those ecosystems, and the species that lived there are explored. **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.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Changes in ecosystems			
Research the effects of an environmental change (e.g., deforestation, climate change, pollution, fire, drought, flooding, decreased oxygen levels) on organisms in an ecosystem. Develop a plan to help return an ecosystem back to its original state (e.g., remediation of riverbanks after a flood, reforestation) or prevent the return of an ecosystem back to its original state (e.g., damming the Mississippi River so it can't revert to its earlier course). Critique plans (written or oral) from different organizations to reintroduce a species into an Ohio ecosystem. Write a newspaper article in support or against the reintroduction of the species based upon scientific facts.	Using a streambed conduct an investigation to determine how erosion and deposition impact organisms in that ecosystem. Explore the effect of glaciation on our landforms by comparing northwestern Ohio with southeastern Ohio.	Use maps of Ohio over several time periods to investigate past and current ecosystems and the organisms that lived in each. Read a first-hand description and/or view drawings of Ohio ecosystems as first observed by explorers and compare the historical environmental descriptions to the current description. Explain changes that occurred in the biotic and abiotic components of the local ecosystem. Check with your local historical society and library for assistance in locating resources for your community. Examine the past ecosystems of your local community and create a visual representation (e.g. storyboard) showing the timeline of the change. Explain the anticipated impact of a change to the ecosystem (e.g., deforestation, fire, pollution, climate change, drought, flooding, decrease in oxygen levels) to the native species and surrounding area.	Describe major changes in Ohio's ecosystems over time and the organisms supported in each (e.g., oceanic, glacial, wetlands, forests).

Grade 4 continued

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

4.LS.2: 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 species that have lived on Earth are extinct.

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

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

Grade 4 Concepts
Fossils provide evidence that many plant and animal species are extinct and other species have changed over time. The types of fossils that are present provide evidence about the nature of an ecosystem at that time. As an ecosystem changed, so did the types of organisms that could survive in that ecosystem.

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 is explored in greater detail. Modern Cell Theory and rock formation are explored.

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

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Fossils			
		Use resources to identify types of fossils and infer the environmental conditions in which an organism may have existed. Classify fossils based on anatomical characteristics and infer behavior patterns and habitats. Research appropriate paleontology dig techniques, tools and procedures to conduct a small-scale simulated archaeological dig through several visually distinct varying layers of sediment.	Identify evidence that can be used to determine the existence of an organism.
Comparing organisms			
Create a reconstruction of an extinct animal using information from the fossil record and examples of animals alive today (e.g., reconstruct the body of a trilobite, including soft tissue, after exploring a trilobite fossil and a living pill bug).		Research the ancestors of an organism living today using fossil evidence. Compare the living organism with its ancestors (e.g., body structure, habitat).	Use fossil evidence to show that organisms existing today have similarities to organisms that lived long ago.

Grade 5

INTRODUCTION TO CONTENT STATEMENTS

GRADE BAND THEME: INTERCONNECTIONS WITHIN SYSTEMS

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

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 This topic focuses on the characteristics, cycles and patterns in the solar system and within the universe.	**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.	**Topic**: **Interactions within Ecosystems** This topic focuses on foundational knowledge of the structures and functions of ecosystems.
CONDENSED CONTENT STATEMENTS		
5.ESS.1 The solar system includes the sun and all celestial bodies that orbit the sun. Each planet in the solar system has unique characteristics. **5.ESS.2** The sun is one of many stars that exist in the universe. **5.ESS.3** Most of the cycles and patterns of motion between the Earth and sun are predictable.	**5.PS.1** The amount of change in movement of an object is based on the mass of the object and the amount of force exerted. **5.PS.2** Light and sound are forms of energy that behave in predictable ways.	**5.LS.1** Organisms perform a variety of roles in an ecosystem. **5.LS.2** All of the processes that take place within organisms require energy.

NATURE OF SCIENCE GRADES 3-5

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	3-5
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Observe and ask questions about the world that can be answered through scientific investigations. • Design and conduct scientific investigations using appropriate safety techniques. • Use appropriate mathematics, tools, and techniques to gather data and information. • Develop and communicate descriptions, models, explanations and predictions. • Think critically and ask questions about the observations and explanations of others. • Communicate scientific procedures and explanations. • Apply knowledge of science content to real-world challenges.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• Science is both a body of knowledge and processes to discover new knowledge. • Science is a way of knowing about the world around us based on evidence from experimentation and observations. • Science assumes that objects and events occur in consistent patterns that are understandable through measurement and observation.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• People from many generations and nations contribute to science knowledge. • People of all cultures, genders, and backgrounds can pursue a career in science. • Scientists often work in teams. • Science affects everyday life. • Science requires creativity and imagination.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science develops theories based on a body of scientific evidence. • Science explanations can change based on new scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Complete *Nature of Science* document is found on pages 8-12.

Grade 5 continued

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

5.ESS.1: 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.

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 appears to change in a single day and from day to day. The sun is the principal source of energy. Earth's atmosphere is discussed.

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

Grade 5 Concepts

Planets in the solar system orbit the sun. Some of the planets have one or more orbiting moons. Earth is a planet that has a moon. The moon orbits Earth. Gravitational forces between the sun and its planets cause the planets to orbit the sun. Gravitational forces between a planet and its moon(s) cause the moon(s) to orbit the planet. If no forces were present, planets and moons would continue their motion toward outer space without changes in speed or direction. However, gravitational forces between the sun and each planet continuously changes the planet's direction so it remains in orbit. In the same way, gravitational forces between each moon and its planet continuously changes the moon's direction so it remains in orbit.

Asteroids are rocky bodies that orbit the sun in nearly circular orbits but are too small to be classified as planets. Comets are a mixture of ices (e.g., water, methane, carbon monoxide, carbon dioxide, ammonia) and dust, and have highly elliptical orbits. A meteor appears when a particle or chunk of metallic or stony matter called a meteoroid enters Earth's atmosphere from outer space. Meteors that pass through the atmosphere and impact Earth's surface are called meteorites.

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.

Future Application of Concepts

Grades 6-8: The interior and exterior composition of Earth, Earth's unique atmosphere, light waves, electromagnetic waves, interactions among 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

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Solar system			
Analyze various online models or student created models of the solar system. Critique the models on their ability to accurately depict the relationships among bodies in the solar system. Choose a planet (other than Earth) or a moon and research and develop a plan to colonize it with humans. Evaluate current conditions and what would be needed to meet the basic requirements for humans to live there. Critique the plan. Ask: Is the plan feasible? What equipment is required? Make a final recommendation based on the research. Present recommendations to the class.	Choose a major planet. Plan and build a scaled model that can demonstrate the planet size, rotation and orbit in relationship to the sun and Earth.	Use a flashlight or other light source as the sun to model various aspects of the sun and Earth movement relationships. 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 the planets. Explore current scientific discussions about how to classify planets (e.g., dwarf vs. regular).	Explain the characteristics of major types of objects that orbit the sun (e.g., planets, comets, meteoroids, asteroids).

Grade 5 continued

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

5.ESS.2: 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 appears to change 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 Earth. Scaled models (3-D or virtual) and graphics can be used to show the vast difference in size between the sun and Earth. The sun is a medium-sized star and is the only star in our solar system. There are many other stars of different sizes in the universe. Because they are so far away, they do not appear as large as the sun. Stars appear in patterns called constellations, which can be used for navigation.

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 Earth and other planets.

Current and new discoveries related to the sun and other stars are included.

Future Application of Concepts
Grades 6-8: Earth's unique atmosphere, light waves, electromagnetic waves, interactions between 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

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
The sun			
	Design and construct a model that shows the relationship between the size of the sun and Earth.	Differentiate between the sun and a red dwarf or blue giant star. Make a table or chart to represent the comparison. Research ways that constellations have been used for navigation throughout history.	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 Earth.

Grade 5 continued

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

5.ESS.3: 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.

Note: *Moon phases should not be the focus.*

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 appears to change 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
In a day Earth rotates once on its axis, which is tilted at a 23.5° angle. Earth's rotation causes the apparent position of the sun, moon and stars to move in the sky from east to west. Some stars are visible from all parts of Earth, some stars can only be seen from the northern hemisphere and some stars can only be seen from the southern hemisphere. Stars located directly above the north and south poles do not appear to move. A well-known example of this is the North Star. The effects of Earth's tilt are not the focus at this level. Direct and indirect sunlight, the reason hours of daylight change throughout the year and the role of Earth's tilt in changing seasons are reserved for grade 7.

Shadows change throughout the day due to the apparent movement of the sun. This content can be linked with content from 5.PS.2.

As Earth orbits the sun, different stars and constellations are visible during different portions of the year. Stars located in the same direction as the sun are not visible because the sun is so bright compared to the other stars. Stars located in the direction opposite from the sun are seen during nighttime hours. As Earth moves in its orbit around the sun, various sections of the sky are visible during nighttime hours. This allows different stars to be seen at different times of the year.

Models, interactive websites and investigations are used to illustrate the predictable patterns and cycles that lead to the understanding of rotation (day and night) and revolution (years).

Future Application of Concepts
Grades 6-8: Earth's unique atmosphere, light waves, electromagnetic waves, interactions between Earth, moon and sun (including the phases of the moon and tides), seasons, 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

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
	Cycles between Earth and the sun		
	Create a sundial and record different shadow positions throughout the day. Analyze the data. Discuss whether the results would be the same in a different global location (e.g., eastern hemisphere, southern hemisphere) or at a different time of year. 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 why the moon has phases. Ask: If we were standing on the moon would Earth have phases?	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.

Grade 5 continued

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

5.PS.1: 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).

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: *Differentiating between mass and weight is not necessary at this grade level.*

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.

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 direction of an object's motion, the speed will increase. If a force is applied in the direction opposite an object's motion, the speed will decrease. The greater the force acting on an object, the greater the change in motion. The greater the mass of an object, the less influence a force will have on its motion. If no force acts on an object (or the forces are balanced), 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 (or the forces are balanced), the object will remain at rest.

A force is described by its strength and the direction that it pushes or pulls an object. More than one force can act on an object at a time. At this grade level, only consider two forces acting on an object either horizontally or vertically. When two forces act on an object, their combined effect influences the motion of that object. The effect forces have on an object depends not only on the forces' strengths, but also on their directions. If the forces have equal strengths, but act in opposite directions, the object's motion will not change, and the forces are considered balanced. A stationary object subject to balanced forces will remain stationary. A moving object subject to balanced forces will continue moving in the same direction at the same speed. Unbalanced forces will cause change in the motion of an object. A stationary object subject to unbalanced forces will move in the direction of the larger force. Inquiry activities should be used to develop student understanding of the effects of forces on the motion of objects.

Movement is a change in position. Speed is a measurement of how fast or slow this change takes place. In the same amount of time, a faster object moves a greater distance than a slower object. Speed is calculated by dividing distance traveled by elapsed time. An object that moves with constant speed travels the same distance in each successive unit of time. When an object is speeding up, the distance it travels increases with each successive unit of time. Speed should be investigated through testing and experimentation. When possible, real-world settings are recommended for the investigations. Virtual investigations, simulations and freeze-frame video also can be used to explore concepts of speed.

Note 2: *While concepts are related to Newton's first and second laws, they should remain conceptual at this grade. Knowing the names of the laws 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 and not be taught as the primary definition of speed.*

Future Application of Concepts
Grades 6-8: Vectors are used to show the magnitude and direction of forces. Position 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. Speed vs. time graphs are used to represent motion.

EXPECTATIONS FOR LEARNING

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Speed			
Design a system to determine the speed of a car. Give an example of how the speed could be calculated from the measurements.	Investigate the relationship between time, speed and distance. Describe patterns for objects moving at constant speed, objects slowing down and object speeding up.	Compare constant and changing speed by reading graphs, tables or using models.	Classify motion as constant speed, speeding up or slowing down based on distance traveled per unit of time. Describe the relationship between time, speed and distance. Identify examples of constant speed, speeding up and slowing down in everyday circumstances (e.g., vehicles traveling, people walking, predator/prey, sports). Use distance traveled in a period of time to calculate speed.
Balanced and unbalanced forces			
	Explore a variety of balanced and unbalanced forces on objects. Identify the forces involved. Describe the strength and direction of the forces and the effect they have on the motion of the objects.	Identify forces based on real life examples found in games and everyday activities (e.g., bowling, baseball, kickball). Identify them as balanced or unbalanced. Design demonstrations to show the effects of balanced and unbalanced forces on objects.	Classify pairs of forces acting on an object as balanced or unbalanced when given various scenarios.
How mass affects motion			
	Investigate the effect of mass on the force required to move an object (e.g., vary the mass of an object and observe the effect of the same force on that object).		Explain that objects with less mass travel farther than those with more mass when pushed with the same force.

Grade 5 continued

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

5.PS.2: 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. 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.

Grades 3-4: Objects with energy can cause motion or create change. Energy can transfer between objects and locations. Light energy from the sun contributes to plant growth.

Grade 5 Concepts

Light can travel through some materials, such as glass or water. Light can also 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 strikes 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. Prisms and magnifying lenses can be used to observe the refraction of light.

Visible light can 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. The additive rules for color mixing of light, other than the fact that white light is a mixture of many colors, are reserved for later grades. The wave nature of sound and light are not introduced at this level nor are parts of the electromagnetic spectrum other than visible light.

Pitch can be altered 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. At this grade, how sound travels through the medium is not appropriate as atoms and molecules are not introduced until grade 6.

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 (reflect) or engage in some combination of these possibilities.

Light travels faster than sound. Technology, virtual simulations and models can help demonstrate the movement of light and sound. Experimentation, testing and investigation (3-D or virtual) are essential components of learning about light and sound properties.

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, as well as the Doppler effect.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Reflection and absorption			
Design a shelter for daytime use on hot sunny days. Design the shelter so that it keeps the inside temperature as cool as possible.	Compare temperatures of a substance (e.g., water, sand) that is heated by a light shining on it at different angles or intensities. Describe the relationship between the angle and the change in temperature.	Explain how we see color due to the reflection and absorption of light.	Identify sources of light as emitted or reflected.
Refraction			
		Demonstrate the refraction of light that results in the separation of colors using a flashlight and prism (or the sun and bubbles).	
Transparent, translucent, and opaque			
Create a model/illustration of a building and explain the usefulness of different materials in the design with relationship to light energy. Identify locations where transparent, translucent and opaque materials are appropriate.		Model the amount of light that can pass through a transparent, translucent or opaque material.	Classify a set of objects as transparent, translucent and opaque.

Grade 5 continued

LIFE SCIENCE (LS)

Topic: Interconnections within Ecosystems
This topic focuses on foundational knowledge of the structures and functions of ecosystems.

CONTENT STATEMENT	CONTENT ELABORATION
5.LS.1: 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.	**Prior Concepts Related to Interactions within Environments** **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 that 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 resembles 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. 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 can be conducted and include considerations of the effects of remediation programs, species loss and the introduction of new species on the local ecosystem. **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."*

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.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Interactions in ecosystems			
Design and build a self-sustaining habitat (e.g., terrarium, bottle biology). Considerations for the habitat include the size of the container, location to create the proper temperature, light and humidity, and organisms that will support one another.		Observe the interaction of two organisms in an ecosystem or on a video. Determine whether they have a symbiotic relationship and, if so, decide which type of symbiotic relationship exists. Support your claim with evidence. Compare a predator-prey relationship to parasitism. 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 ecosystem, classify them as producers, consumers, or decomposers. Given a list of organisms and a description of their interactions within an ecosystem, recognize and identify examples of symbiosis (e.g., mutualism, commensalism and parasitism).

Grade 5 continued

LIFE SCIENCE (LS)

Topic: Interconnections within Ecosystems
This topic focuses on foundational knowledge of the structures and functions of ecosystems.

CONTENT STATEMENT	CONTENT ELABORATION
5.LS.2: 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 is used or stored by the producer and can be passed from organism to organism as illustrated in food webs.	**Prior Concepts Related to Interactions within Environments** **PreK-2:** Living things have basic needs, which are met by obtaining materials from physical ecosystems. **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 the sun to photosynthetic organisms to consumers (herbivores, omnivores, 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. Direct and remote sensing (e.g., satellite imaging and other digital-research formats) can be used to help visualize what happens in an ecosystem when new producers, including invasive species, enter 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:** The details of photosynthesis are addressed in Biology.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Organisms acquire and use energy			
	Design an investigation that will measure changes in heart rate related to physical activity or exercise.	Research how the muscular, respiratory and cardiovascular systems work together during physical activity and relate to energy use.	Given a list of common organisms and a description of their interactions in an ecosystem, draw a food web using arrows to illustrate the flow of energy. Properly identify the producers and consumers.
Ecosystem changes			
Critique a plan to reintroduce a species into an Ohio ecosystem (e.g., sauger, salamander, sturgeon, northern riffleshell mussel). Provide evidence to support or oppose the reintroduction of the species based upon scientific facts.		Explain the effects of altering specific factors (e.g., number of predators, rainfall, invasive species) in an ecosystem and the effect it has on organisms. Explain ways that humans can improve the health of ecosystems (e.g., recycling wastes, establishing rain gardens, planting native species).	Describe how an invasive species can be harmful to an ecosystem.

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 inferred from simple principles. These principles are related to the properties or interactions within and between systems.

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 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.	**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.	**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.
CONDENSED CONTENT STATEMENTS		
6.ESS.1 Minerals have specific, quantifiable properties. **6.ESS.2** Igneous, metamorphic and sedimentary rocks have unique characteristics that can be used for identification and/or classification. **6.ESS.3** Igneous, metamorphic and sedimentary rocks form in different ways. **6.ESS.4** Soil is unconsolidated material that contains nutrient matter and weathered rock. **6.ESS.5** Rocks, mineral and soils have common and practical uses.	**6.PS.1** Matter is made up of small particles called atoms. **6.PS.2** Changes of state are explained by a model of matter composed of particles that are in motion. **6.PS.3** There are two categories of energy: kinetic and potential. **6.PS.4** An object's motion can be described by its speed and the direction in which it is moving.	**6.LS.1** Cells are the fundamental unit of life. **6.LS.2** All cells come from pre-existing cells. **6.LS.3** Cells carry on specific functions that sustain life. **6.LS.4** Living systems at all levels of organization demonstrate the complementary nature of structure and function.

NATURE OF SCIENCE HIGH SCHOOL

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	High School
Scientific Inquiry, Practice and Applications All students must use these 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 using a variety of methods and tools to collect empirical evidence, observing appropriate safety techniques. • Use technology and mathematics to improve investigations and communications. • Formulate and revise explanations and models using logic and scientific evidence (critical thinking). • Recognize and analyze explanations and models. • Communicate and support scientific arguments.

Science is a Way of Knowing
Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.
	• Various science disciplines use diverse methods to obtain evidence and do not always use the same set of procedures to obtain and analyze data (i.e., there is no one scientific method).
	  o Make observations and look for patterns.
	  o Determine relevant independent variables affecting observed patterns.
	  o Manipulate an independent variable to affect a dependent variable.
	  o Conduct an experiment with controlled variables based on a question or hypothesis.
	  o Analyze data graphically and mathematically.
	• Science disciplines share common rules of evidence used to evaluate explanations about natural phenomenon by using empirical standards, logical arguments and peer reviews.
	  o Empirical standards include objectivity, reproducibility, and honest and ethical reporting of findings.
	  o Logical arguments should be evaluated with open-mindedness, objectivity and skepticism.
	• Science arguments are strengthened by multiple lines of evidence supporting a single explanation.
	• The various scientific disciplines have practices, methods, and modes of thinking that are used in the process of developing new science knowledge and critiquing existing knowledge.

Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Science depends on curiosity, imagination, creativity and persistence. • Individuals from different social, cultural, and ethnic backgrounds work as scientists and engineers. • Science and engineering are influenced by technological advances and society; technological advances and society are influenced by science and engineering. • Science and technology might raise ethical, social and cultural issues for which science, by itself, does not provide answers and solutions.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science can advance through critical thinking about existing evidence. • Science includes the process of comparing patterns of evidence with current theory. • Some science knowledge pertains to probabilities or tendencies. • Science should carefully consider and evaluate anomalies (persistent outliers) in data and evidence. • Improvements in technology allow us to gather new scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

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. Students should be able to calculate mass, volume or density, given two of the three values.

PS.M.2: Atoms
Content introduced in middle school, where the atom was introduced as a small, indestructible sphere, is further developed in this course. 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. An atom is empty space with a very small positively charged nucleus. The nucleus is composed of protons and neutrons. The electrons move about in the empty space that surrounds the nucleus. Although current understanding goes beyond the Bohr Model, it can still be used to represent the atom and develop the idea of valence electrons. Experimental evidence that led to the development of historic atomic models is reserved for Chemistry.

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. Atomic mass calculations and explanations about configuration of electrons and how atomic spectra are produced are reserved for Chemistry.

PS.M.3: Periodic trends of the elements
Content from the middle school level, specifically the properties of metals, nonmetals and metalloids and their positions on the periodic table, is further expanded in this course. The periodic table was arranged so that elements with similar chemical and physical properties are in the same group or family. 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. Trends in simple observable properties, like density or melting point, can be examined within families or groups on the periodic table. These trends allow scientists to make predictions about new elements. 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 reserved for Chemistry.

PS.M.4: Bonding and compounds
Middle school content introduced the concept that compounds are composed of atoms of two or more different 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 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, and writing formulas/naming compounds that contain polyatomic ions or transition metals are reserved for Chemistry.

PS.M.5: 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 reserved for Chemistry.

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.

Nuclear reactions involve changes to the nucleus and typically produce much larger energies than chemical reactions. The strong nuclear force is an 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. Nuclei that undergo this process are said to be radioactive. Radioactive decay can result in the release of different types of radiation (alpha, beta, gamma), each with a characteristic mass, charge, and potential to alter and penetrate the material it strikes. Alpha decay changes the identity of the element. Beta decay results from the decay of a neutron. When a radioisotope undergoes alpha or beta decay, the resulting nucleus can be predicted and the balanced nuclear equation can be written.

For any radioisotope, the half-life is unique and predictable. 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. Only whole number integers of half-lives will be addressed in this course.

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 elements in the universe beyond hydrogen and is the source of energy in the sun and other stars. Using nuclear reactions as an energy resource can be addressed. Further details about nuclear processes, including mass-energy equivalence and nuclear power applications, are addressed in Physics.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
PS.M.1: Classification of matter			
Heterogeneous vs. homogeneous			
Devise a method to purify water in developing countries.	Design a procedure to separate a homogeneous or heterogeneous mixture.	Using data from various physical separation techniques, construct a particle diagram for a mixture based on the particulate nature of matter.	Identify samples of matter as homogeneous or heterogeneous (e.g., salt water, chicken noodle soup).
Properties of matter			
	Investigate the effect of various factors (e.g., temperature, surface area of solute, stirring) on the rate materials (e.g., sugar cubes, salt crystals) dissolve.	Explain the process of burning a candle in terms of physical and chemical changes. Compare acids and bases found in the home (e.g., household cleaning products, soaps, coffee, soda, vinegar, fruit juices, antacids) using experimentally determined pH data from meters or from universal indicators.	Explain the location of acids, bases and neutral substances on the pH scale.
States of matter and its changes			
		Using a phase change diagram determine the phase of water and other substances at different temperatures.	Identify the various phase changes and classify them as endothermic or exothermic.

<table>
<tr><th>Designing technological/engineering solutions using science concepts</th><th>Demonstrating science knowledge</th><th>Interpreting and communicating science concepts</th><th>Recalling accurate science</th></tr>
<tr><td colspan="4">PS.M.2: Atoms</td></tr>
<tr><td></td><td>Design and implement a procedure to test for the presence of common dissolved ions.</td><td>Research cations and anions and how they function in everyday products (e.g., hair products, car washes, dryer sheets).

Describe the difference between hard and soft water.

Model the formation of ions with particle diagrams or manipulatives.

Interpret the presence of dissolved ions in water with respect to human health.</td><td>Describe the location, charge, and relative size of a proton, neutron, and electron.

Use information from the periodic table to calculate numbers of protons, neutrons and electrons for an element. Use this information to draw a Bohr model of the element.

Define isotope and provide an example.

Explain the importance of valence electrons.

Use the periodic table and/or electron dot diagrams to identify the ionic charge of elements in groups 1, 2, 17, and 18.</td></tr>
<tr><td colspan="4">PS.M.3: Periodic trends of the elements</td></tr>
<tr><td>Design an alternate arrangement of elements in the periodic table.</td><td></td><td>Develop a flow chart or dichotomous key to identify a substance as a metal, nonmetal or metalloid.

Explain the differences between the properties/ionic charge of 2 elements chosen from groups 1, 2, 17, and 18.</td><td>Using the periodic table and/or electron dot diagrams, identify the ionic charge of elements in groups 1, 2, 17, and 18.

Explain why elements are grouped into families.

Identify metals, nonmetals, metalloids, alkali metals, alkaline earth metals, halogens and noble gases based on their positions on the periodic table.</td></tr>
</table>

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
PS.M.4: Bonding and compounds			
Bonding (ionic and covalent)			
		Using modeling, compare ionic and covalent compounds in terms of molecular and three-dimensional lattice formation.	Describe how ionic and covalent bonds are formed in terms of valence electrons. Given elements and their locations on the periodic table, predict if they will form ionic or covalent compounds.
Nomenclature			
		Use naming conventions to find an example of a covalent compound and an ionic compound in an ingredient list. Explain why having a standard set of naming and formula writing rules is important.	Name the Greek prefixes 1-10. Given two elements, predict the chemical formula and name of an ionic compound (e.g., calcium and chlorine = $CaCl_2$ = calcium chloride). Name binary covalent molecules and binary ionic compounds when given formulas. Determine the formulas for covalent molecules and binary ionic compounds when given their names.
PS.M.5: Reactions of matter			
Chemical reactions			
		Explain why Na + Br_2 yields NaBr and not $NaBr_2$. Investigate safe chemical reactions (e.g., vinegar and baking soda in a Ziploc bag) to determine if they are exothermic or endothermic.	Give an example where temperature change is observable without measurement, where temperature change is observable with a thermometer, and where temperature change is impossible to measure. Balance a chemical equation when provided the formulas of reactants and products.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Nuclear reactions			
		Use the half-life of C-14 to explain appropriate uses of carbon dating. Describe how the radioactive isotopes of several elements are used in medical testing. Describe the short- and long-term effects of nuclear wastes on the environment. Research and interpret the consequences, information and technology involved in the discovery or synthesis of new elements. Include historical references (e.g., Madame Curie).	Describe alpha, beta and gamma radiation. Compare nuclear fission and nuclear fusion. Identify applications of radioisotopes.

Physical Science continued

PS.EW: ENERGY AND WAVES
PS.EW.1: Conservation of energy
- Quantifying kinetic energy
- Quantifying gravitational potential energy

PS.EW.2: Transfer and transformation of energy (including work)
PS.EW.3: Waves
- Refraction, reflection, diffraction, absorption, superposition
- Radiant energy and the electromagnetic spectrum
- Doppler shift

PS.EW.4: Thermal energy
PS.EW.5: Electricity
- Movement of electrons
- Current
- Electric potential (voltage)
- Resistors and transfer of energy

CONTENT ELABORATION: 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.

PS.EW.1: 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 $E_k = ½mv^2$. Gravitational potential energy, E_g, can be mathematically represented by $E_g = mgh$. The amount of gravitational potential 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 (e.g., 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) should be provided.

PS.EW.2: Transfer and transformation of energy (including work)

In middle school, concepts of energy transfer and transformation were addressed. Topics included conservation of energy, conduction, convection and radiation, the transformation of electrical energy, and the dissipation of energy into thermal energy. Work 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, Δx, are in the same or opposite directions, work, W, can be calculated from the equation $W = F\Delta x$. Work can also be quantified as $W = \Delta E$. 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; conceptual understanding of kinetic energy, potential energy and work should be emphasized. 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.

PW.EW.3: 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. These concepts were applied to seismic waves traveling through different materials. 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 conceptually addressed (not mathematically) 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 from 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 and 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 Physics, 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 continuously 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 that have different applications in everyday life: radio (lowest energy), microwaves, infrared, visible light, ultraviolet, X-rays and gamma rays (highest energy).

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). Total radiant energy depends on more than just the frequency. Radiant energy exhibits wave behaviors including reflection, refraction, absorption, superposition and diffraction. 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 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 illustrated by listening to an ambulance siren as it travels past. As discussed in the Universe section of this course, this phenomenon is important to current understanding of how the universe is expanding. As a result, the light we receive from distant galaxies has a noticeable shift toward redder wavelengths (the so-called "redshift"). Calculations to measure the apparent change in frequency or wavelength are not appropriate for this course.

PS.EW.4: 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, were 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 continuously 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 will be quantified for substances that change their temperature.

PS.EW.5: Electricity

In earlier grades, concepts of electrical conductors and insulators were introduced. A complete loop is needed for an electrical circuit that may be in parallel or in series. In this course, 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). An ampere 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) are used to construct a variety of circuits and to measure and compare the potential difference (voltage) and current. Circuits are dealt with conceptually in this course. Calculations are reserved for Physics.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
PS.EW.1: Conservation of energy			
	Devise a procedure to calculate the speed of an object at constant velocity using a meter stick and a stopwatch or a frame-by-frame motion video. Use measured speed and mass to calculate kinetic energy.		Calculate potential energy given an object's mass and its height above a reference point. Calculate the kinetic energy of a moving object given the mass and velocity. Calculate the drop heights of objects based on their velocity at impact. Explain how the gravitational potential energy of an object varies based on the position of the reference point. Use the principle of conservation of energy to solve for an unknown quantity in a problem (e.g., beginning gravitational potential energy equals final kinetic energy for a falling object).
PS.EW.2: Transfer and transformation of energy (including work)			
	Design and conduct an investigation to estimate the energy lost (dissipated) in each bounce of a bouncing ball.	Use data to explain energy transformations occurring in a closed system.	Calculate the amount of work done by a force applied to an object. Calculate the amount of work transferred into or out of a system using changes in energy.
Awesome roller coaster design			
Design and build a roller coaster with at least two loops and one hill. Use the roller coaster to calculate kinetic and potential energy and identify the quantity of energy transferred out of the system during the ride. Then engineer a new design that would decrease the energy loss from the system.	Design a method to estimate the energy transferred to the surrounding environment as thermal energy through work done by frictional forces.	Label the rollercoaster to identify places where energy is converted from one type to another (e.g., where kinetic energy is being converted into gravitational potential energy). Explain how the gravitational potential energy of an object varies based on the position of the reference point.	Calculate the velocity at the bottom and top of each hill based on conservation of energy. Measure the velocity of the object at the bottom of each hill. Compare the measured velocity to the calculated velocity.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
PS.EW.3: Waves			
Design an experiment to investigate radiant energy transmission, absorption, and reflection with a variety of materials (e.g., opaque, transparent, rough, smooth). 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.	Construct a model to compare mechanical waves and electromagnetic waves. Research an observable wave phenomenon and design a demonstration to present to the class.	Give examples and illustrate wave behaviors including reflection, refraction, absorption, diffraction, and superposition. Identify the placement of each type of wave (e.g., gamma, x-ray, ultraviolet, visible, infrared, micro, radio) along the electromagnetic spectrum. Compare the relative wave energy, frequency and wavelength of different regions of the electromagnetic spectrum. Describe how the Doppler shift effect can produce a change in frequency for sound waves. Explain how sound or radiant waves are used in medicine or everyday life applications (e.g., ultrasound, lasers, x-rays).	Design an experiment to investigate radiant energy transmission, absorption, and reflection with a variety of materials (e.g., opaque, transparent, rough, smooth).
PS.EW.4: Thermal Energy			
Design a "cooler" cooler			
Use thermal conductivity concepts to improve a cooler design to keep beverages cold. Improve the design of the cooler to further reduce the transfer of thermal energy.	Design a method to investigate the thermal conductivity of potential materials to be used in the design.	Graphically compare potential materials based on the results of the investigations.	Differentiate between a thermal insulator and a thermal conductor. Provide examples of each.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
PS.EW.5 - Electricity			
Given several circuit boards where current does not flow, determine why the current is not flowing and implement a solution to resolve the problem. Design a circuit that produces the maximum amount of light from a given set of materials (e.g., light bulbs, LEDs, various lengths of wires, batteries).	Design an investigation to determine the relationship between potential difference and current through a resistor.	Illustrate electric flow in parallel and series circuits. Explain situations where each type of circuit is more advantageous. Explain how resistance is an important concept in an engineering design context (e.g., determining how many light fixtures a circuit can handle, understanding how lack of insulation can cause short circuits).	Differentiate how electrons move in an insulator vs. a conductor. Compare the flow of electrons in a circuit to the flow of electrical energy. Analyze a circuit or schematic, to determine if it is a series or parallel circuit. Define and measure current, voltage and resistance. Explain that cells are joined together to form a battery. Explain conceptually how batteries generate electric current.
Design an electrically powered alarm system.			
Design an alarm system that uses a change in a circuit to indicate that the alarm has been triggered, (e.g., a short circuit changing current flow through a branch, a branch of a circuit opening to cease current flow).		Explain how the system sets off the alarm in terms of changes in current or potential difference in the circuit.	

Physical Science continued

PS.FM: FORCES AND MOTION
PS.FM.1: Motion

- Introduction to one-dimensional vectors
- Displacement, velocity (constant, average and instantaneous) and acceleration
- Interpreting position vs. time and velocity vs. time graphs

PS.FM.2: Forces

- Force diagrams
- Types of forces (gravity, friction, normal, tension)
- Field model for forces at a distance

PS.FM.3: Dynamics (how forces affect motion)

- Objects at rest
- Objects moving with constant velocity
- Accelerating objects

CONTENT ELABORATION: FORCES AND MOTION

Building upon content in elementary and middle school, major concepts of motion and forces are further developed. In middle school, speed was addressed conceptually, mathematically and graphically. The concepts that forces have both magnitude and direction and can be represented with force diagrams, that forces can be added to find a net force and that forces may affect motion have 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 this course, motion is limited to segments of uniform motion (e.g., at rest, constant velocity, constant acceleration) in a straight line either horizontally, vertically, up an incline or down an incline. Motions of two objects may be compared or addressed simultaneously (e.g., when or where would they meet).

PS.FM.1: 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 acceleration on motion diagrams is 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 quantity 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. Velocity should be distinguished from speed, which is always positive. 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.

Acceleration is a vector quantity that represents the rate at which velocity changes. Average acceleration can be calculated by dividing the change in velocity 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 Physics. Deceleration is an ambiguous term that should only be used when an object is slowing down. Care should

be given to ensure students do not associate negative acceleration with only deceleration. Objects with negative acceleration could be increasing their speed. 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 this course, graphs will be limited to positive x-values and show only uniform motion involving segments of constant velocity or constant acceleration. Motion can be investigated by collecting and analyzing data in the laboratory and should include constant velocity as well as constant acceleration. 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 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 can also 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 a constant velocity) will have a 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.

PS.FM.2: Forces
Force is a vector quantity, having both magnitude and direction. Force diagrams are useful tools for visualizing and analyzing the forces acting on objects. 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 can also be represented as $kg·m/s^2$. The opportunity to measure force in the lab is 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, gravitational, electric and magnetic) can be used as examples of forces that affect motion.

In this course, only forces in one dimension (positive and negative) will be addressed. The net force can be determined by one-dimensional vector addition. Gravitational force (weight) can be calculated from mass, but all other forces will only be quantified from force diagrams. Friction is a force that opposes motion. Kinetic friction (e.g., sliding, rolling), drag and static friction can be addressed conceptually. More quantitative study of friction forces, universal gravitational forces, elastic forces and electrical forces is reserved for Physics.

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 ladder leaning against a wall, a ball hitting a bat). 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.

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. In high school, the field concept is further developed. 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, F_g, can be calculated from the equation $F_g = mg$, where g is the gravitational field strength of an object which is equal to 9.8 N/kg or 9.8 m/s^2 on the surface of Earth.

PS.FM.3: Dynamics (how forces affect motion)
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. When the vector sum of the forces (net force, F_{net}) 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.

An object will accelerate (increase or decrease its speed or change its direction of motion) when 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 forces (net force, F_{net}) and inversely proportional to the mass ($a = F_{net}/m$).

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, for this level, 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. In Physics, all laws will be applied to systems of many objects.

EXPECTATIONS FOR LEARNING

The content in the standards needs to be taught in ways that incorporate the nature of science and engage students in scientific thought processes. Where possible, real-world data and problem- and project-based experiences should be utilized. *Ohio's Cognitive Demands* relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. Care should be taken to provide students opportunities to engage in all four types of thinking. Additionally, lessons need to be designed so that they incorporate the concepts described in the *Nature of Science*.

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
		PS.FM.1: Motion	
	Conduct an investigation to determine the acceleration of a freely falling object.	Given real-world examples, explain how the frame of reference of an observer affects the appearance of motion. Create a velocity vs. time graph for an object using data from its position vs. time graph. Write a story describing an object's motion that corresponds to a velocity vs. time graph.	Identify examples of data that are vector quantities and examples of data that are scalar quantities. Determine the displacement of an object in one dimension, as measured from a frame of reference. Describe how an object can have a distance that is not the same as the displacement. Distinguish average velocity from instantaneous velocity. Calculate the velocity of an object by measuring the time to travel different distances and determine if the object moves with constant or changing velocity. Calculate the acceleration of an object from its change in speed during a given time interval. On a velocity vs. time graph, identify when an object is showing no motion, constant velocity and constant acceleration. Given a position vs. time graph, velocity vs. time graph, or acceleration vs. time graph identify the other corresponding graphs.
		Speed detection device	
Build a model of a device that could be used to determine the speed of a car travelling down the street.	Design a system or method to collect the data needed to calculate the speed of a car travelling down the street.	Present to the class how data will be measured and how it will be used to determine the speed of the car.	Decide what data must be collected to determine the speed of a car.

Biology

INTRODUCTION AND SYLLABUS

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 three units of science.. Each course should include 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.

COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

B.H: HEREDITY

B.H.1: Cellular genetics
B.H.2: Structure and function of DNA in cells
B.H.3: Genetic mechanisms and inheritance
B.H.4: Mutations
B.H.5: Modern genetics

B.E: EVOLUTION

B.E.1: Mechanisms
- Natural selection
- Mutation
- Genetic drift
- Gene flow (immigration, emigration)
- Sexual selection

B.E.2: Speciation
- Biological classification expanded to molecular evidence
- Variation of organisms within species due to population genetics and gene frequency

B.DI: DIVERSITY AND INTERDEPENDENCE OF LIFE

B.DI.1: Biodiversity
- Genetic diversity
- Species diversity

B.DI.2: Ecosystems
- Equilibrium and disequilibrium
- Carrying capacity

B.DI.3: Loss of Diversity
- Climate change
- Anthropocene effects
- Extinction
- Invasive species

B.C: CELLS

B.C.1: Cell structure and function
- Structure, function and interrelatedness of cell organelles
- Eukaryotic cells and prokaryotic cells

B.C.2: Cellular processes
- Characteristics of life regulated by cellular processes
- Photosynthesis, chemosynthesis, cellular respiration, biosynthesis of macromolecules

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Microscopy			
	Collect and analyze microscopic organisms from a local pond or stream. Infer evolutionary relationships between organisms according to ancestral traits and derived characteristics like cell parts and multicellularity.	Create a graphic organizer consisting of various cells and cell structures. Organize them according to size. Investigate how each would appear under different types of microscopes.	
Homeostasis and feedback loop			
Research the cause and effect of various homeostatic diseases (e.g., Type 2 diabetes, high blood pressure, gout) and develop solutions to achieve homeostatic balance for patients that suffer from this disease. Suggest an explanation for the increased incidence of diabetes worldwide.	Plan and conduct an investigation that identifies or manipulates feedback mechanisms to maintain homeostasis. Investigations could include heart rate response to exercise, stomate response to moisture and temperature and root development in response to water levels.	Illustrate a model of negative or positive feedback including a sensor, a control center, effectors and variables being regulated.	Compare negative and positive feedback mechanisms.
B.C.2: Cellular Processes			
Fermentation			
Refine a product such as yogurt so that it better addresses dietary concerns, restraints and restrictions (e.g. diabetics, infants, bodybuilders).	Design a lab studying yeast and adjust variables such as temperature, pH and food sources. Use probes or other methods to measure gas exchange.	Provide data from fermentation activities (e.g., Kombucha, sauerkraut) and evaluate variables and outcomes.	Identify the cellular organelles involved in fermentation. Include inputs and outputs required for the process.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
	Biosynthesis of macromolecules		
Plan and design an investigation using algae, fungi or other microorganisms to biosynthesize a natural product that has commercial applications.	Research various biomolecules found in food. Investigate a food source and identify its biomolecule components. Evaluate and critique popular food options on the market and determine if the nutritional analysis is factual. Using nutritional data create a new marketing promotion for healthier food choices and present findings.	Research various techniques to extract oil or hormones from algae. Infer the structural changes (e.g., cellular inclusions, smooth endoplasmic reticulum proliferation) to the algal cells that these techniques may cause. Which strains of algae utilize the most cost-efficient metabolic pathways for oil or hormone production?	Construct models of various biomolecules. Identify basic building blocks, functions, and location of biomolecules in food and/or the environment.
	Enzymes		
	Plan and design an investigation to determine the factors (e.g., temperature, pH, substrate concentration) that affect the activity of enzymes on their substrates (e.g., peroxidase). Research diseases caused by enzymatic deficiencies and propose possible solutions or evaluate how medical breakthroughs have solved the problem (e.g., lactase persistence, adrenoleukodystrophy, mitochondrial disorders).	Using a simulation or data predict the effects of different variables (e.g., temperature, pH, salinity) on enzyme structure and function. Given a graph, interpret and analyze activation energy with optimal pH and temperature.	Identify the structure and function of enzymes and substrates applying models such as lock and key or induced fit.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Photosynthesis and respiration			
Promote awareness of photosynthetic processes as a component of the Earth's CO_2 recycling system. Design a "green" environment (e.g., school, house, microenvironment) that demonstrates sustainable environmental practices, such as vegetated green roof systems to improve air quality. The design should encompass the efficient use of fuel resources and building materials to lower carbon footprint and reduce greenhouse gas emissions. Generate an argument and present data justifying how the design improves sustainability.	Design experiments to study gas exchange in photosynthetic organisms. Analyze the data generated to justify which environmental conditions are the most efficient for the photosynthetic organisms. Probes could be used to measure gas exchange.	Generate a model to depict the role of photosynthesis and cellular respiration in the cycling of matter and energy through biogeochemical cycles.[1]	Identify key organelles, as well as the inputs and outputs of matter and energy, utilized by photosynthesis and cellular respiration.

[1] National Geographic Website-The Earth Has Lungs This website uses satellite imagery to demonstrate the vast planetary breathing system—a giant green machine that pulls enormous quantities of carbon dioxide out of the air, especially in the warmer months. This site is useful for demonstrating the effect of photosynthesis on the Earth's CO_2 recycling system.

Chemistry

INTRODUCTION AND SYLLABUS

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 three units of science. Each course should include 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.

COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

C.PM: STRUCTURE AND PROPERTIES OF MATTER

C.PM.1: Atomic structure
- Evolution of atomic models/theory
- Electrons
- Electron configurations

C.PM.2: Periodic Table
- Properties
- Trends

C.PM.3: Chemical bonding
- Ionic
- Polar/covalent

C.PM.4: Representing compounds
- Formula writing
- Nomenclature
- Models and shapes (Lewis structures, ball and stick, molecular geometries)

C.PM.5: Quantifying matter

C.PM.6: Intermolecular forces of attraction
- Types and strengths
- Implications for properties of substances
  - Melting and boiling point
  - Solubility
  - Vapor pressure

C.IM: INTERACTIONS OF MATTER

C.IM.1: Chemical reactions
- Types of reactions
- Kinetics
- Energy
- Equilibrium
- Acids/bases

C.IM.2: Gas laws
- Pressure, volume and temperature
- Ideal gas law

C.IM.3: Stoichiometry
- Molecular calculations
- Solutions
- Limiting reagents

NATURE OF SCIENCE HIGH SCHOOL

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	High School
Scientific Inquiry, Practice and Applications All students must use these 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 using a variety of methods and tools to collect empirical evidence, observing appropriate safety techniques. • Use technology and mathematics to improve investigations and communications. • Formulate and revise explanations and models using logic and scientific evidence (critical thinking). • Recognize and analyze explanations and models. • Communicate and support scientific arguments.

Science is a Way of Knowing
Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.
	• Various science disciplines use diverse methods to obtain evidence and do not always use the same set of procedures to obtain and analyze data (i.e., there is no one scientific method).
	  o Make observations and look for patterns.
	  o Determine relevant independent variables affecting observed patterns.
	  o Manipulate an independent variable to affect a dependent variable.
	  o Conduct an experiment with controlled variables based on a question or hypothesis.
	  o Analyze data graphically and mathematically.
	• Science disciplines share common rules of evidence used to evaluate explanations about natural phenomenon by using empirical standards, logical arguments and peer reviews.
	  o Empirical standards include objectivity, reproducibility, and honest and ethical reporting of findings.
	  o Logical arguments should be evaluated with open-mindedness, objectivity and skepticism.
	• Science arguments are strengthened by multiple lines of evidence supporting a single explanation.
	• The various scientific disciplines have practices, methods, and modes of thinking that are used in the process of developing new science knowledge and critiquing existing knowledge.

Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Science depends on curiosity, imagination, creativity and persistence. • Individuals from different social, cultural, and ethnic backgrounds work as scientists and engineers. • Science and engineering are influenced by technological advances and society; technological advances and society are influenced by science and engineering. • Science and technology might raise ethical, social and cultural issues for which science, by itself, does not provide answers and solutions.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science can advance through critical thinking about existing evidence. • Science includes the process of comparing patterns of evidence with current theory. • Some science knowledge pertains to probabilities or tendencies. • Science should carefully consider and evaluate anomalies (persistent outliers) in data and evidence. • Improvements in technology allow us to gather new scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Limiting reagents			
Evaluate an environmental problem through the lens of limiting reagents (e.g., algae growths impacted by available phosphates and nitrates). Investigate the role that limiting reagents play in an industrial process (e.g., pharmacology, cosmetics, chemical industries). Evaluate techniques to optimize production, including how costs and waste products are taken into consideration.	Plan and carry out an investigation to demonstrate the conceptual principle of limiting reactants.	Compare limiting to excess reagents in a chemical reaction (e.g., copper (II) sulfate and an iron nail).	Determine which reactant is limited using particle diagrams. Use BCA tables to calculate the quantities of products and excess reactants.

Environmental Science

INTRODUCTION AND SYLLABUS

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 three units of science. Each course should include 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.

COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

EARTH SYSTEMS: INTERCONNECTED SPHERES OF EARTH

ENV.ES.1: Biosphere
- Evolution and adaptation in populations
- Biodiversity
- Ecosystems (equilibrium, species interactions, stability)
- Population dynamics

ENV.ES.2: Atmosphere
- Atmospheric properties and currents

ENV.ES.3: Lithosphere
- Geologic events and processes

ENV.ES.4: Hydrosphere
- Oceanic currents and patterns (as they relate to climate)
- Surface and ground water flow patterns and movement
- Cryosphere

ENV.ES.5: Movement of matter and energy through the hydrosphere, lithosphere, atmosphere and biosphere
- Energy transformation on global, regional and local scales
- Biogeochemical cycles
- Ecosystems
- Weather
- Climate

EARTH'S RESOURCES

ENV.ER.1: Energy resources
- Renewable and nonrenewable energy sources and efficiency
- Alternate energy sources and efficiency
- Resource availability
- Mining and resource extraction

ENV.ER.2: Air and air pollution
- Primary and secondary contaminants
- Greenhouse gases
- Clean Air Act

ENV.ER.3: Water and water pollution
- Potable water and water quality
- Hypoxia, eutrophication
- Clean Water Act
- Point source and non-point source contamination

ENV.ER.4: Soil and land
- Desertification
- Mass movement and erosion
- Sediment contamination
- Land use and land management (including food production, agriculture and zoning)
- Solid and hazardous waste

ENV.ER.5: Wildlife and wilderness
- Wildlife and wilderness management
  - Endangered species
- Invasive Species
- Introduced Species

ENV.GP: GLOBAL ENVIRONMENTAL PROBLEMS AND ISSUES

ENV.GP.1: Human Population
ENV.GP.2: Potable water quality, use and availability
ENV.GP.3: Climate change
ENV.GP.4: Sustainability
ENV.GP.5: Species depletion and extinction
ENV.GP.6: Air quality
ENV.GP.7: Food production and availability
ENV.GP.8: Deforestation and loss of biodiversity
ENV.GP.9: Waste management (solid and hazardous)

NATURE OF SCIENCE HIGH SCHOOL

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	High School
Scientific Inquiry, Practice and Applications All students must use these 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 using a variety of methods and tools to collect empirical evidence, observing appropriate safety techniques. • Use technology and mathematics to improve investigations and communications. • Formulate and revise explanations and models using logic and scientific evidence (critical thinking). • Recognize and analyze explanations and models. • Communicate and support scientific arguments.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• Various science disciplines use diverse methods to obtain evidence and do not always use the same set of procedures to obtain and analyze data (i.e., there is no one scientific method). o Make observations and look for patterns. o Determine relevant independent variables affecting observed patterns. o Manipulate an independent variable to affect a dependent variable. o Conduct an experiment with controlled variables based on a question or hypothesis. o Analyze data graphically and mathematically. • Science disciplines share common rules of evidence used to evaluate explanations about natural phenomenon by using empirical standards, logical arguments and peer reviews. o Empirical standards include objectivity, reproducibility, and honest and ethical reporting of findings. o Logical arguments should be evaluated with open-mindedness, objectivity and skepticism. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation. • The various scientific disciplines have practices, methods, and modes of thinking that are used in the process of developing new science knowledge and critiquing existing knowledge.
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Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science can advance through critical thinking about existing evidence. • Science includes the process of comparing patterns of evidence with current theory. • Some science knowledge pertains to probabilities or tendencies. • Science should carefully consider and evaluate anomalies (persistent outliers) in data and evidence. • Improvements in technology allow us to gather new scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Environmental Science continued

ENV.ES: EARTH SYSTEMS: INTERCONNECTED SPHERES OF EARTH
ENV.ES.1: Biosphere

- Evolution and adaptation in populations
- Biodiversity
- Ecosystems (equilibrium, species interactions, stability)
- Population dynamics

ENV.ES.2: Atmosphere

- Atmospheric properties and currents

ENV.ES.3: Lithosphere

- Geologic events and processes

ENV.ES.4: Hydrosphere

- Oceanic currents and patterns (as they relate to climate)
- Surface and ground water flow patterns and movement
- Cryosphere

ENV.ES.5: Movement of matter and energy through the hydrosphere, lithosphere, atmosphere and biosphere

- Energy transformations on global, regional and local scales
- Biogeochemical cycles
- Ecosystems
- Weather
- Climate

CONTENT ELABORATION: EARTH SYSTEMS: INTERCONNECTED SPHERES OF EARTH

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. In this course, the focus is on the connections and interactions between Earth's spheres (the hydrosphere, atmosphere, biosphere and lithosphere). Both natural and anthropogenic interactions are 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., volcanic activity 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 are researched and investigated using actual data. The emphasis is on the interconnectedness of Earth's spheres and the understanding of the complex relationships between them, 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 among Earth's spheres.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.GP.8: Deforestation and loss of biodiversity			
Design a community of the future that demonstrates responsible practices for preservation of biodiversity and forested areas.	Use satellite mapping resources (NASA Forest Changes in Rondonia, Brazil) to investigate the connection between urbanization, population growth and deforestation. Summarize your findings.	Write a proposal for the state setting limits/regulations for housing/commercial development through the lens of biodiversity. Consider federal laws. Develop a PSA on commercial products that contribute to deforestation (e.g., palm oil) and how deforestation contributes to the loss of biodiversity. Engage in a classroom discussion on the rationale and methods to reduce the deer population in an Ohio community. Complete a graphic organizer on various tree harvesting practices (e.g., clear cutting, seed tree cutting, selective cutting, slash & burn) including a description of economic and ecological advantages and disadvantages of each.	Identify areas where urban sprawl has impacted plant, wildlife and human communities. Describe the effects on biodiversity.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
ENV.GP.9: Waste management (solid and hazardous)			
Develop a risk assessment for humans or the environment due to a toxin or hazardous chemical used by a company. The assessment should include: nature of the toxin/chemical, on-site use and handling (including existing safety practices), by-products (e.g., vapors, dilution processes), storage, transportation and emergency plans. Consider the topography and geology of the area and how these contribute to the flow of spills or leaks. Use a computer-modeling program (many are available through freeware sites) to model and predict the movement and possible pathways of the toxin/chemical. Make recommendations for containment methods. Research composting techniques. Analyze the wastes produced by the school and design an appropriate composting system to process the biodegradable waste produced. Construct and maintain a composting site on school grounds.	Conduct a landfill decomposition study over an extended period to determine the rate at which typical materials found in landfills decompose.	Collect research information on various waste management types. Compare and contrast the practices of waste management of developed and developing nations. Compare methods of at least two different nations and identify the best practices. Research the waste management issues and the root causes for the problems that face the local community, Ohio, the United States or the world. Plan and implement an investigation to explore human health issues related to the disposal of hazardous waste materials (e.g., biomagnification or bioaccumulation within a specific Ohio ecosystem). Existing public case studies can be used, such as a local Brownfields case.	Document the amount of waste a family/individual produces throughout a 24-hour period. Identify the materials that are non-recyclable and recyclable. Describe the benefits and challenges of recycling. Draw a diagram of a modern landfill and label the various components that are required or used in landfills today to prevent them from polluting the air and water.

Physical Geology

INTRODUCTION AND SYLLABUS

COURSE DESCRIPTION

Physical Geology 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 three units of science. Each course should include 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.

COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

PG.M: MINERALS

PG.M.1: Atoms and elements
PG.M.2: Chemical bonding (ionic, covalent, metallic)
PG.M.3: Crystallinity (crystal structure)
PG.M.4: Criteria of a mineral (crystalline solid, occurs in nature, inorganic, defined chemical composition)
PG.M.5: Properties of minerals (hardness, luster, cleavage, streak, crystal shape, fluorescence, flammability, density/specific gravity, malleability)

PG.IMS: IGNEOUS, METAMORPHIC AND SEDIMENTARY ROCKS

PG.IMS.1: 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)

PG.IMS.2: 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)

PG.IMS.3: Sedimentary
- Division of sedimentary rocks and minerals (chemical, clastic/physical, organic)
- Depositional environments

PG.IMS.4: 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
- Transgressing and regressing sea levels
- Streams (channels, streambeds, floodplains, cross-bedding, alluvial fans, deltas)

PG.EH: EARTH'S HISTORY

PG.EH.1: 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

PG.PT: PLATE TECTONICS

PG.PT.1: Internal Earth
- Seismic waves
  - S and P waves
  - Velocities, reflection, refraction of waves

PG.PT.2: 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)

PG.PT.3: Historical review (Note: this would include a review of continental drift and seafloor spreading found in grade 8)
- Paleomagnetism and magnetic anomalies
- Paleoclimatology

PG.PT.4: 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
- Mantle plumes

PG.ER: EARTH'S RESOURCES

PG.ER.1: Energy resources
- Renewable and nonrenewable energy sources and efficiency
- Alternate energy sources and efficiency
- Resource availability
- Mining and resource extraction

PG.ER.2: Air
- Primary and secondary contaminants
- Greenhouse gases

PG.ER.3: Water
- Potable water and water quality
- Hypoxia, eutrophication

PG.ER.4: Soil and sediment
- Desertification
- Mass wasting and erosion
- Sediment and contamination

PG.GG: GLACIAL GEOLOGY

PG.GG.1: 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

NATURE OF SCIENCE HIGH SCHOOL

Nature of Science
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Categories	High School
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Physics

INTRODUCTION AND SYLLABUS

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 three units of science. Each course should include 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.

COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

P.M: MOTION

P.M.1: Motion Graphs
- Position vs. time
- Velocity vs. time
- Acceleration vs. time

P.M.2: 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)

P.M.3: Projectile Motion
- Independence of horizontal and vertical motion
- Problem-solving involving horizontally launched projectiles

P.F: FORCES, MOMENTUM AND MOTION

P.F.1: Newton's laws applied to complex problems
P.F.2: Gravitational force and fields
P.F.3: Elastic forces
P.F.4: Friction force (static and kinetic)
P.F.5: Air resistance and drag
P.F.6: Forces in two dimensions
- Adding vector forces
- Motion down inclines
- Centripetal forces and circular motion

P.F.7: Momentum, impulse and conservation of momentum

P.E: ENERGY

P.E.1: Gravitational potential energy
P.E.2: Energy in springs
P.E.3: Work and power
P.E.4: Conservation of energy
P.E.5: Nuclear energy

P.W: WAVES

P.W.1: Wave properties
- Conservation of energy
- Reflection
- Refraction
- Interference
- Diffraction

P.W.2: Light phenomena
- Ray diagrams (propagation of light)
- Law of reflection (equal angles)
- Snell's law
- Diffraction patterns
- Wave—particle duality of light
- Visible spectrum of color

NATURE OF SCIENCE HIGH SCHOOL

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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 are 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

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VISIONS INTO PRACTICE: CLASSROOM EXAMPLES

This section provides guidance for developing classroom tasks that go beyond traditional approaches to instruction. It is a springboard for generating innovative ideas to address the cognitive demands. A variety of activities are presented so that teachers can select those that best meet the needs of their students. This is not an all-inclusive checklist and is not intended to cover every aspect of the standards. **These activities are suggestions and are not mandatory.**

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
P.W.1: Wave properties			
Design a parabolic cooker using principles of ray reflection to design the apparatus. After construction and testing, evaluate the success of the design and examine where performance departs from plan.	Plan and conduct an investigation of wave diffraction. Use single or double slit diffraction to experimentally investigate light waves.	Solve problems related to constructive and destructive interference between two waves. Graphically represent the locations where constructive and destructive interference are occurring based on the path of each wave. Calculate the distances mathematically.	Solve problems involving standing waves on strings and in open and closed pipes. Explain the conditions required for standing waves to occur. Calculate the frequency of a standing wave of a given harmonic.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
P.EM.3: Electric fields and electric potential energy			
	Use a computer simulation to investigate the effect of charges on the electric field at a point in space and the effect of an external field on a charged particle. Determine the relationships.	Compare Earth's gravitational field with an electric field in terms of when potential energy is increasing and decreasing. Explore the Millikan Oil Drop Experiment. Apply the idea of equilibrium to electrical and gravitational forces.	Solve problems about the force on a charged particle in a constant electric field. Use Newton's Laws, kinematic equations and equations for work and kinetic energy to calculate the acceleration of the particle, the final velocity of the particle and the change in energy of the particle. Describe the relationship between potential energy and electric fields. Draw the field lines for a positive charge, a negative charge, a dipole and two parallel plates of charge.
P.EM.4: DC circuits			
	Use a source of constant voltage to plan and conduct an investigation to determine the relationship between the current and the resistance 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.	Solve problems involving complex circuits with arrangements of resistors in both parallel and series to determine the equivalent resistance of the entire circuit as well as the current, the potential difference, or rate of energy dissipated in individual resistors in the circuit. Compare different types of string lights to explore what type of circuits are involved, how blinker bulbs work and how bulbs that are unlit complete a circuit.	Solve problems involving resistors in series and in parallel to determine the current, potential difference, or rate of energy dissipated in individual resistors in the circuit.
P.EM.5: Magnetic fields			
		Use a small compass to map the magnetic field around a bar magnet, horseshoe magnet and circular magnet. Explain why the shape of the fields is different.	

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
P.EM.6: Electromagnetic interactions			
Design and build a generator that will convert mechanical energy into electrical energy and light three flashlight bulbs. 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. Design an electromagnetic motor with a limitation on the amount of materials used in construction. Test the design and redesign the motor based on the findings from the testing process.	Investigate the production of a magnetic field by a current carrying wire. Develop and test a hypothesis about the relationship between an independent variable (e.g., amount of current) and the strength of the generated magnetic field. Using a galvanometer connected to a solenoid and a magnet, design and conduct an investigation to determine when current is induced and what variables affect the strength of the current.	Apply Newton's Laws to predict the shape of the path followed by a charged particle moving in a magnetic field. Draw the path and predict the shape for heavier and lighter particles as well as particles with different charge. Predict the direction of a magnetic field in a current carrying wire. Use a compass and wire demonstration device to check the prediction.	State the factors that affect the force on a moving charged particle in a magnetic field and determine the path taken by the charged particle. Use the right-hand rules to determine the direction of a charged particle in a magnetic field. Discuss the benefits and origins of Earth's magnetic field.
Determining unknown resistance			
	Plan and conduct an investigation to determine the resistance of an unknown resistor. Unanticipated effects on measurements should be accounted for (e.g., internal resistance of the battery or power supply) and assumptions made should be explained (e.g., assuming the resistance of the wires can be ignored or that a voltmeter has an infinite impedance). Experimental design should be checked for safety before conducting the experiment.	Draw a circuit diagram of the experimental design before conducting the experiment, labeling the elements of the circuit.	Calculate the resistance of the resistor, using either an average of the data or by graphing the data and analyzing it.

Human Anatomy and Physiology

INTRODUCTION AND SYLLABUS

COURSE DESCRIPTION

Human Anatomy and Physiology 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 three units of science. Each course should include inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

Human Anatomy and Physiology comprises a systematic study in which students will examine human anatomy and physical functions. They will analyze descriptive results of abnormal physiology and evaluate clinical consequences. A workable knowledge of medical terminology will be demonstrated.

COURSE CONTENT

The following information may be taught in any order; there is no ODE-recommended sequence.

AP.LO: LEVELS OF ORGANIZATION

AP.LO.1: Hierarchy of Organization
AP.LO.2: Types of Tissues
AP.LO.3: Homeostasis
AP.LO.4: Anatomical Terminology

AP.SM: SUPPORT AND MOTION

AP.SM.1: Integumentary System
AP.SM.2: Skeletal System
AP.SM.3: Muscular System

AP.IC: INTEGRATION AND COORDINATION

AP.IC.1: Nervous System
AP.IC.2: Special Senses

- Sense of Sight
- Senses of Hearing and Balance
- Senses of Taste and Smell

AP.IC.3: Endocrine System

AP.T: TRANSPORT

AP.T.1: Blood
AP.T.2: Cardiovascular System
AP.T.3: Lymphatic and Immune Systems

AP.AE: ABSORPTION AND EXCRETION

AP.AE.1: Digestive System
AP.AE.2: Respiratory System
AP.AE.3: Urinary System

AP.R: REPRODUCTION

AP.R.1: Reproductive System

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Human Anatomy and Physiology continued

AP.LO: LEVELS OF ORGANIZATION
AP.LO.1: Hierarchy of organization
AP.LO.2: Types of tissues
AP.LO.3: Homeostasis
AP.LO.4: Anatomical terminology

CONTENT ELABORATION: LEVELS OF ORGANIZATION

AP.LO.1: Hierarchy of organization
Building on knowledge about cell structures and processes from middle school and Biology, this topic focuses on the increasing complexity of cells as they are organized into tissues. Several tissue types make up an organ. Several organs working together make up an organ system. All the organ systems interact and form the human body.

AP.LO.2: Types of tissues
The human body is comprised of four types of tissues: epithelial, connective, muscle and nervous. This topic includes a broad overview of the structure, function and location of each tissue type. Tissues can be studied as an independent unit or as they are encountered within each organ system. Investigations are used to understand and explain types of tissues in a variety of inquiry and design scenarios that can incorporate evolutionary concepts, scientific reasoning, comparative analysis, communication skills and real-world applications.

AP.LO.3: Homeostasis
Homeostasis is a theme that is explored throughout the course. Homeostasis involves positive and negative feedback mechanisms that continuously monitor and adjust the body's internal conditions (e.g., temperature regulation, pH, hormone regulation, blood pressure, hemostasis). At times, there can be a disruption (or disruptions) in the feedback loops, creating an imbalance. This homeostatic imbalance can result in a variety of conditions.

AP.LO.4: Anatomical terminology
Standard anatomical position is to be used as a reference point. Each area of the human body is identified by region. The features and structures of the body, relative to each other, are described by directional terms. The body and its organs can be divided by planes. The organs are located in cavities.

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AP.R.1: Reproductive system			
Design an artificial womb (ectogenesis) that could support embryonic life.	Examine how environmental variables can impact sea urchin fertilization.	Develop a visual graphic with a timeline indicating the evolution of reproductive physiology in mammals from egg laying monotremes, marsupials and then placental mammals. Display the current global distribution of monotreme, marsupial and placental mammals. Propose one or more hypotheses to explain these observed distribution patterns. Interpret information from a case study to discuss the misconception that all menstrual cycles last 28 days. Design a poster or similar graphic to inform peers of the global, human population over the last 5,000 years.	Identify the structures of the male reproductive system and the functions of each structure. Identify the structures of the female reproductive system and the functions of each structure. Explain the pathway of a gamete through each reproductive system. Compare the processes of oogenesis and spermatogenesis.