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 GRADE 6-8

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

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

Grade 6 continued

EARTH AND SPACE SCIENCE (ESS)

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

CONTENT STATEMENT	CONTENT ELABORATION
6.ESS.1: Minerals have specific, quantifiable properties. Minerals are naturally occurring, inorganic solids that have a defined chemical composition. Minerals have properties that can be observed and measured. Minerals form in specific environments. **Note:** *The emphasis is on learning how to identify the mineral by conducting tests (not through memorization).*	**Prior Concepts Related to Mineral Properties** **PreK-2:** Objects have physical properties. Properties of objects can change. Earth's nonliving resources have specific properties. **Grades 3-5:** Rocks and soil have characteristics. Soil contains pieces of rocks. Objects are composed of matter and may exhibit electrical conductivity and magnetism. **Grade 6 Concepts** Most rocks are composed of one or more minerals. Minerals have specific properties that can be used for identification. The properties that can be used for testing minerals include luster, hardness, cleavage, streak, magnetism, fluorescence and/or crystal shape. At this grade level, common minerals (including those on Mohs hardness scale) are used in the identification process. A representative sample of minerals should be used so that different testing methods can be applied and demonstrated. Appropriate tools and safety procedures must be used when testing mineral properties. Technology can provide identification information and research materials to assist in mineral investigations. Mineral composition can help identify rocks. Minerals can indicate the type of environment in which the rock and/or mineral formed. Some minerals (e.g., feldspar varieties, magnetite, varieties of quartz) form in an igneous environment, some minerals (e.g., epidote) form in a metamorphic environment, and some form in a sedimentary environment (e.g., chalk, calcite). Some minerals (e.g., halite, varieties of gypsum, calcite) form through evaporation and a variety of chemical processes. **Future Application of Concepts** **Grades 7-8:** Biogeochemical cycles, igneous environments and the history of Earth (including the changing environments) from the interpretation of the rock record are studied. **High School:** The formation of elements, chemical bonding and crystal structure are found in the physical sciences. In Physical Geology, mineralogy is explored in depth.

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
Minerals			
Given a variety of minerals design an investigation to determine the best one to use to polish a surface (e.g., make an arrowhead, sand wood, polish marble).	Simulate the formation of halite or gypsum in the Lake Erie area. Using data from the evaporate simulation predict how long it took to form the existing formations.	Explain the likely environmental conditions that existed when a specified mineral was formed based on its properties (e.g., halite and gypsum in the Lake Erie area). Make a dichotomous key of mineral properties for testing and identifying minerals. Compare rocks and minerals.	Identify properties, using tests, of common rock-forming minerals (e.g., calcite, halite, dolomite, gypsum, quartz, feldspar, mica, talc, kaolinite, chalk, topaz, corundum, pyrite, magnetite, epidote, hornblende). Sort minerals by identifying common properties such as luster, hardness, streak, cleavage, magnetism, fluorescence and/or crystal shape. Identify the different processes and/or environments in which minerals can form (e.g., evaporation, chemical processes, sedimentary, igneous or metamorphic). Explain that minerals have measurable properties that can be used for identification and/or classification.

Grade 6 continued

EARTH AND SPACE SCIENCE (ESS)

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

CONTENT STATEMENT	CONTENT ELABORATION
6.ESS.2: Igneous, metamorphic and sedimentary rocks have unique characteristics that can be used for identification and/or classification. Most rocks are composed of one or more minerals, but there are a few types of sedimentary rocks that contain organic material, such as coal. The composition of the rock, types of mineral present, and/or mineral shape and size can be used to identify the rock and to interpret its history of formation, breakdown (weathering) and transport (erosion).	**Prior Concepts Related to Rocks** **PreK-2:** Objects have physical properties. Properties of objects can change. Earth's nonliving resources have specific properties. **Grades 3-5:** Rocks and soil have characteristics. Soil contains pieces of rocks. Rocks form in different ways. Objects are composed of matter and may exhibit electrical conductivity and magnetism. **Grade 6 Concepts** The purpose of rock identification is related to understanding the environment in which the rock formed. Rock identification and classification are experiential and investigative. Common samples to use in identification should be representative of each type of rock. Igneous samples include varieties of granite, rhyolite, basalt, obsidian, pumice and andesite. Metamorphic samples include varieties of schist, gneiss, slate, marble, anthracite and phyllite. Sedimentary samples include varieties of limestone, sandstone, shale, conglomerate and breccia. Other rock samples such as bituminous coal, coquina and chert can also be included in identification investigations, but these may not always fall neatly into one specific rock category. Proper safety protocol and testing procedures must be used. It is important to use the identification of the minerals and quantifiable characteristics of the rock to identify the rock. Analysis of specific rock characteristics can be conducted in the classroom or in nature with rock samples. Technology can be used to research current identification methods and techniques to assist in determining the quantifiable characteristics of specific rocks. **Future Application of Concepts** **Grades 7-8:** Sedimentary, metamorphic and igneous environments, and the history of Earth (including the changing environments) from the interpretation of the rock record are studied. **High School:** The formation of elements, chemical bonding and crystal structure are found in the physical sciences. In Physical Geology, depositional environments, volcanism, characteristics of rocks and mineralogy are explored in depth.

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Designing technological/engineering solutions using science concepts	**Demonstrating science knowledge**	**Interpreting and communicating science concepts**	**Recalling accurate science**
Rocks			
Determine the best mineral or rock to use to solve a problem (e.g., neutralize acidic soil, make a statue). Evaluate the results and use the data to draw a conclusion.		Analyze the characteristics of rocks used locally (e.g., in landscape projects, buildings, floors, statues, gravestones, patios/walls). Make a chart, table or key to use in the classification of common rocks within each division of rock (sedimentary, igneous, metamorphic).	Recognize that each type of rock has a unique history based upon the environmental conditions that existed when it formed.

Grade 6 continued

EARTH AND SPACE SCIENCE (ESS)

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

CONTENT STATEMENT	CONTENT ELABORATION
6.ESS.3: Igneous, metamorphic and sedimentary rocks form in different ways. Magma or lava cools and crystallizes to form igneous rocks. Heat and pressure applied to existing rock forms metamorphic rocks. Sedimentary rock forms as existing rock weathers chemically and/or physically and the weathered material is compressed and then lithifies. Each rock type can provide information about the environment in which it was formed.	**Prior Concepts Related to Rocks** **PreK-2:** Objects have physical properties. Properties of objects can change. Earth's nonliving resources have specific properties. **Grades 3-5:** Rocks and soil have characteristics. Soil contains pieces of rocks. Rocks form in different ways. Objects are composed of matter and may exhibit electrical conductivity and magnetism. **Grade 6 Concepts** Rocks and minerals in rocks form in specific types of environments. The rock cycle can be used for a general explanation of the conditions required for igneous, metamorphic and sedimentary rocks to form, but additional information should be added for relevancy. For example, the typical pattern of coal formation is connected to energy in Ohio and should be included. Another example would be the formation of Ohio sandstone and limestone indicating that a shallow sea once covered Ohio. Ohio's geologic history and past environmental conditions play a role in understanding the existing bedrock in Ohio. Field investigations, virtual field trips, geologic maps, physical maps and topographic maps can be used to illustrate how types of geologic structures and features help identify the types of rock that may be found in specific areas. This should be connected to an understanding of the environmental conditions that existed during the formation. **Future Application of Concepts** **Grades 7-8:** Sedimentary, metamorphic and igneous environments, and the history of Earth (including the changing environments) from the interpretation of the rock record are studied. **High School:** The formation of elements, chemical bonding and crystal structure are found in the physical sciences. In Physical Geology, depositional environments, volcanism, characteristics of rocks and mineralogy are explored in depth. In Environmental Science, geological events and processes are explored as related to the lithosphere.

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
Igneous, metamorphic and sedimentary rocks			
Make a geologic map of the local community. Use existing geologic data and field exploration to analyze types of formations/deposits that are present. Use the finished map to evaluate possible land and resource uses.	Based on the environment required for specific rock types to form, develop a hypothesis regarding the geologic history of a specific region. Cite evidence to support the hypothesis.	Use a geologic map of a region to determine what types of rocks are represented (igneous, sedimentary, metamorphic). Explain why those types of rocks might be found in that area. Compare multiple rock samples and hypothesize the environment or conditions in which they likely formed.	Identify the main processes of the rock cycle. Illustrate the process of formation of igneous, sedimentary, and metamorphic rock. Identify the likely environments or conditions of formation of igneous, sedimentary, and metamorphic rocks.

Grade 6 continued

EARTH AND SPACE SCIENCE (ESS)

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

CONTENT STATEMENT	CONTENT ELABORATION
6.ESS.4: Soil is unconsolidated material that contains organic matter and weathered rock. Soil formation occurs at different rates and is based on environmental conditions, types of existing bedrock and rates of weathering. Soil forms in layers known as horizons. Soil horizons can be distinguished from one another based on properties that can be measured. The terms dirt and soil are not synonymous, use the term "soil". **Note:** *The emphasis should be on properties of soil rather than memorization.*	**Prior Concepts Related to Soil** **PreK-2:** Objects have physical properties. Properties of objects can change. Earth's nonliving resources have specific properties. **Grades 3-5:** Rocks and soil have characteristics. Soil contains pieces of rocks. Soil investigations measure color, texture, ability for water to pass through soil, moisture content and soil composition. Objects are composed of matter. **Grade 6 Concepts** Soil sampling and testing should be used to investigate soil. Soils form at different rates and has different measurable properties, depending on environmental conditions. Properties of soil that are useful in soil identification include texture, color, composition, permeability and porosity. Uses of soils depend upon their properties. For example, some soils may be recommended for agriculture, while others may be used for brick making or creating a pond. Observing and identifying soil horizons are based on understanding the different properties of soil and when the properties change. Soil sample testing methodology and equipment are included within this content statement. Soil maps combined with geologic, aerial or topographic maps can assist in local identification of soil formations. A connection can be made to environmental conditions, types of bedrock and soil properties. Appropriate tools and safety procedures must be used in all soil investigations. **Future Application of Concepts** **Grades 7-8:** Biogeochemical cycles and the role of soil within them, soil erosion and runoff issues, hydrologic cycle including percolation and infiltration rates, and sedimentary environments are studied. **High School:** The formation of elements, the importance of soil in an ecosystem, and issues with soil degradation and soil loss are explored. In Physical Geology, depositional environments, soil mechanics, issues with mass movement including soil/sediment contamination issues and the classification of soil is found.

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
Soil			
During some flooding events, sandbags are used to slow or redirect floodwaters. Develop a list of criteria required for the bags. Using four or five soil samples, design and conduct an investigation to determine which soil is best to use inside the sandbags. Analyze the soil data and test results to make the final determination.	Compare a specific and identifiable soil horizon in different locations within a community. Compare the depth of the soil horizons. Explain the differences that are measured. Identify appropriate land uses for each location. Plan and implement an investigation to determine which types of soil (e.g., sand, clay, loam, silt, gravel) are most likely to fail in a landslide event. Analyze the data and write a conclusion.	Discuss how soil depletion impacts different soil horizons which in turn impact the environment (e.g., the dust bowl, desertification, mass movement, erosion).	Identify the properties that can be measured in soil. Identify the characteristics of each horizon that makes up soil. Compare the different soil horizons (O, A, B and C) using the standard composition of each. Identify the types of conditions that may contribute to the formation of soil or lack of formation of soil. Use tools to measure soil characteristics and properties (e.g., permeability, porosity, texture, color).

Grade 6 continued

EARTH AND SPACE SCIENCE (ESS)

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

CONTENT STATEMENT	CONTENT ELABORATION
6.ESS.5: Rocks, minerals and soils have common and practical uses. Nearly all manufactured material requires some kind of geologic resource. Most geologic resources are considered nonrenewable. Rocks, minerals and soil are examples of geologic resources that are nonrenewable.	**Prior Concepts Related to Rocks, Minerals and Soil** **PreK-2:** Objects have physical properties. Properties of objects can change. Earth's nonliving resources have specific properties. **Grades 3-5:** Rocks and soil have characteristics. Earth's resources can be used for energy. Earth has renewable and nonrenewable resources, some of which are limited. **Grade 6 Concepts** Rocks, minerals and soils have specific physical properties that determine how they can be used. The different methods of extracting the resources can be included. Uses of the resources include construction (e.g., gypsum, metals, gravel, sand, lime, clay), energy (e.g., fossil fuels, radioactive materials), transportation (e.g., road salt, road materials), agriculture (e.g., lime, peat, minerals for fertilizers), domestic use (e.g., metals and gems for jewelry, clay for pottery or sculpting, natural dyes for clothing or paint) and technology (e.g., lithium, silica). The conservation of resources through their management is an important part of understanding the uses of rocks, minerals and soil. Aspects to consider include extraction methods and remediation of the sites and resource use, reuse, storage and disposal. Nonrenewable energy sources can also be included (such as fossil fuels). **Future Application of Concepts** **Grades 7-8:** Biogeochemical cycles (including the hydrologic cycle) are related to erosion and weathering of rock, minerals and soil. The history of Earth (including the formation of fossil fuels) from the interpretation of the rock record is studied. **High School:** The formation of elements, chemical bonding and nuclear energy are found in the physical sciences. In Physical Geology, Earth's resources and specific laws pertaining to the resources are explored at a greater depth. In Environmental Science, geological events and processes are explored as related to the lithosphere.

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**
Uses of geologic resources			
During some flooding events, sandbags are used to slow or redirect floodwaters. Develop a list of criteria required for the bags. Using four or five soil samples, design and conduct an investigation to determine which soil is best to use inside the sandbags. Analyze the soil data and test results to make the final determination.	Plan and implement an investigation to determine which type of soil (e.g., sand, clay, loam, silt, gravel) is most appropriate for a particular construction project (e.g. housing development, park, levee, pond). Analyze the data and write a conclusion.	Make a map or 3-D model of Ohio that illustrates the major geologic resources that are found. Share the final product with the class.	Identify examples of different ways that soil, rocks and minerals can be used.

Grade 6 continued

PHYSICAL SCIENCE (PS)

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

CONTENT STATEMENT

6.PS.1: Matter is made up of small particles called atoms.

Matter has mass, volume and density and is made up of particles called atoms.

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

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

CONTENT ELABORATION

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

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

Grade 6 Concepts
Matter is made of atoms, which are particles that are too small to be seen, even with a light microscope. Matter has properties of mass and volume. Mass measures the amount of matter in an object (e.g., a wood block) or substance (e.g., water), and volume measures the three-dimensional space that matter occupies. Mass can be measured with a balance. The volume of solids can be determined by water displacement or calculated from the dimensions of a regular solid.

Equal volumes of different substances usually have different masses. Some materials, like lead or gold, have a lot of mass in a relatively small space. Other materials, like packing peanuts and air, have a small mass in a relatively large amount of space. This concept of comparing substances by the amount of mass the substance has in a given volume is known as density. While the mass and volume of a material can change depending upon how much of the material there is, the density generally remains constant, no matter how much of the material is present. Therefore, density can be used to identify a material. Mass vs. volume graphs can be constructed and interpreted to determine which material has the greater density. Mathematical calculations of density are not the focus at this grade level and should be delayed until students have a conceptual understanding of density.

An element is a chemical substance that cannot be broken down into simpler substances. There are approximately 90 different naturally occurring elements that have been identified. There are additional elements that were made in a laboratory, but these elements are not stable. All atoms of any one element are alike but are different from atoms of other elements. Atoms of elements can join together to form molecules.

Note: *The structure of the atom, including protons, neutrons and electrons, is not the focus at this grade level; it is addressed in high school physical sciences.*

Future Application of Concepts
Grades 7-8: Differences between pure substances and mixtures are explored. Elements in the periodic table can be classified as a metal, nonmetal or metalloid based on their properties and position on the periodic table. Atoms can be joined together to form separate molecules or large three-dimensional networks.

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

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
Matter			
Design and construct a device (e.g., lava lamp) to demonstrate the relationship between temperature and density.	Devise a method to prove or disprove the statement "*The density of a given substance remains constant.*" Share evidence to support your conclusion.	Graph mass vs. volume for water and a variety of other substances to compare their densities.	Define mass, volume, and density of an object. Using two objects with either the same mass or the same volume, explain conceptually which object has a greater density. Explain the relationship between elements and molecules.

Grade 6 continued

PHYSICAL SCIENCE (PS)

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

CONTENT STATEMENT

6.PS.2: Changes of state are explained by a model of matter composed of particles that are in motion.

Temperature is a measure of the average motion of the particles in a substance.

Heat is a process of energy transfer rather than a type of energy. Energy transfer can result in a change in temperature or a phase change.

When substances undergo changes of state, atoms change their motion and position.

Note: *It is not the intent of this standard to encourage vocabulary identification (matching definitions with heat, temperature, and thermal energy). Instead, these are provided as conceptual tools for understanding the role of energy in physical, biotic, atmospheric, oceanic, and geologic systems covered in grade 6 and subsequent grades and courses.*

CONTENT ELABORATION

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

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

Grade 6 Concepts
Thermal energy can be thought of as the total amount of kinetic energy present in a substance or system through the random motion of its atoms and molecules. Thermal energy depends on the amount of the substance, whereas temperature does not depend on the amount of the substance. When two samples of the same material have the same mass, the sample having the higher temperature will have a greater thermal energy (e.g., a hot nickel has more thermal energy than a cold nickel). When two samples of the same material have the same temperature, the sample with the greater mass will have the greater thermal energy (e.g., a bucket of water has more thermal energy than a cup of water at the same temperature).

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

During phase changes, both the temperature and the mass of the substance remain constant. Particles (atoms and molecules) are not created or destroyed. There is simply a change in the motion of and spacing between the particles. Experiments and investigations (3-D and virtual) are used to demonstrate phase changes. Since moving atoms cannot be observed directly, provide the opportunity to experiment with temperature, phase changes and particle motion using virtual labs.

Future Application of Concepts
Grades 7-8: Mixtures and pure substances are investigated. Elements are classified as metals, nonmetals or metalloids based on their properties and position on the periodic table. Atoms can be joined together into separate molecules or large three-dimensional networks.

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
States of matter			
	Develop and test a hypothesis about the behavior of three different states of matter in a closed retractable space (e.g., using a syringe, observe and record data when a solid, like a marshmallow, and a liquid is placed inside the chamber). Observe and graph the change in temperature during phase changes. Measure mass before and after a phase change. Discuss molecular position and motion in a substance as the phase change occurs.	Explain in terms of the atomic theory why gases can be easily compressed, while liquids and solids cannot. Explain how the arrangement of atoms determines the specific properties (e.g., compressibility, ability to take the shape of a container) of solids, liquids and gases.	Identify three states of matter. Describe the motion and arrangement of atoms for each state of matter Describe the changes in atoms' motion and position when substances undergo changes of state. Describe the relationship between temperature and thermal energy. Describe how mass affects thermal energy (e.g., compare the thermal energy of two samples of the same material with different masses which are at the same temperature).

Grade 6 continued

PHYSICAL SCIENCE (PS)

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

CONTENT STATEMENT	CONTENT ELABORATION
6.PS.3: There are two categories of energy: kinetic and potential. Objects and substances in motion have kinetic energy. Objects and substances can have energy as a result of their position (potential energy). **Note:** *Chemical and elastic potential energy should not be included at this grade; this is found in PS grade 7.*	**Prior Concepts Related to Energy** **PreK-2:** A variety of sounds and motions are experienced. The sun is the principal source of energy. Plants get energy from sunlight. **Grades 3-5:** Objects with energy have the ability to cause change. Thermal energy, electrical energy, light, sound and magnetic energy are forms of energy. Earth's renewable and nonrenewable resources can be used for energy. All processes that take place within organisms require energy. **Grade 6 Concepts** There are many forms of energy, but all can be put into two categories: kinetic and potential. Kinetic energy is associated with the motion of an object. The kinetic energy of an object changes when its speed changes. Potential energy is the energy of relative position between two interacting objects. Potential energy transforms to kinetic energy and vice versa as the distance between objects changes. Using the word "stored" to define potential energy is misleading. The word "stored" implies that the energy is kept by the object and not given away to another object. Therefore, kinetic energy also can be classified as "stored" energy. A rocket moving at constant speed through empty space has kinetic energy and is not transferring any of this energy to another object. Gravitational potential energy is associated with the height of an object above a reference position. The gravitational potential energy of an object changes as its height above the reference changes. Thermal energy can be thought of as the total amount of kinetic energy a substance has because of the random motion of its atoms and molecules. Sound energy is associated with the back and forth movement of the particles of the medium through which it travels. Opportunities to explore many types of energy should be provided. Virtual experiments that automatically quantify energy can be helpful since using measurements to calculate energy is above grade level. **Future Application of Concepts** **Grades 7-8:** Conservation of energy and methods of energy transfer, including waves, are introduced. Chemical and elastic potential energy are explored. **High School:** Standard formulas are used to calculate energy for different objects and systems.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Energy transfers in a device			
Design and build a system that uses moving water to cause a wheel to turn. Describe how this can be used to perform a task. Develop evaluation criteria and use them to compare the effectiveness of the waterwheels built by the class. Determine which design features are most effective and propose an explanation for why these features are effective. Redesign the water wheel to incorporate the best design practices.	Use the waterwheel to investigate the relationship between a variable (e.g., flow rate, volume of water) and the spin rate of the wheel.	Document the design process for the waterwheel including reasons for design decisions for each part, documentation of prototypes developed and the results of testing. Graphically represent the data collected from the investigation (e.g., water load, spin rate).	Classify the energy at each stage in the function of the waterwheel as kinetic, potential or a combination of the two. Explain the changes in energy that occur when the waterwheel is in operation.
Gravitational potential energy			
Design a roller coaster to demonstrate energy transformation between potential and kinetic.	Compare objects as they fall from various heights. Analyze the data to determine patterns and trends. Formulate a conclusion about the relationship between height and gravitational potential energy.	Outline and explain the energy changes involved in dropping an object onto the floor.	Recognize that increasing height increases gravitational potential energy. Recall that an object can have potential energy due to its position relative to another object and can have kinetic energy due to its motion.

Grade 6 continued

PHYSICAL SCIENCE (PS)

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

CONTENT STATEMENT

6.PS.4: An object's motion can be described by its speed and the direction in which it is moving.

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

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

CONTENT ELABORATION

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

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

Grade 6 Concepts
Speed can be calculated by dividing distance traveled by the elapsed time or can be found as the unit rate from a position versus time graph. This content aligns with mathematics standard 6.RP.3. When speed is calculated from a distance measurement, the distance is always measured from some reference point. To describe the motion of an object more thoroughly, the direction of motion can be indicated along with the speed.

Experiments and graph creation/interpretation can be used to investigate motion. Plotting time on the horizontal (x) axis and position on the vertical (y) axis creates a graph that can be used to compare and analyze motion. On position versus time graphs, fast motion is represented by steep lines, slow motion is represented by lines that are less steep, and no motion is represented by horizontal lines. The relative speeds and positions of different objects can be determined by comparing their position vs. time graphs. At this grade level, position vs. time graphs are used to interpret motion data, not as a set of rules to be memorized. Motion detectors can be used to compare the graphs resulting from different types of motion.

Note 2: *Using the word "vector" and exploring other aspects of vectors are not appropriate at this grade level. This content is a precursor to the introduction of vectors*.

Note 3: *At this grade level, interpretations of position vs. time graphs should be limited to comparing lines with different slopes to indicate whether objects are moving relatively fast, relatively slow or not moving at all. Calculation of slope is not appropriate at this grade level. More complex interpretations of position vs. time graphs will be made at higher grade levels.*

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

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

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Motion			
Given a mousetrap car and a recording method (e.g., motion detector), redesign the car so it will move to produce a steeper or less steep position vs. time graph.	Use data (e.g., from motion detectors) to produce distance vs. time graphs to investigate the effects of changes (e.g., steeper ramp, more batteries, harder push, heavier object) made to a moving object. Compare the graphs to determine relative speeds.	Graph an object's motion by measuring and recording its position over time. Use the unit rate of a position vs. time graph to determine the speed of an object moving at constant speed.	Given the distance traveled and the elapsed time, calculate the average speed of an object. Describe motion as the change over time in the position of an object compared to a reference point

Grade 6 continued

LIFE SCIENCE (LS)

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

CONTENT STATEMENT	CONTENT ELABORATION
6.LS.1: Cells are the fundamental unit of life. All living things are composed of cells. Different body tissues and organs are made of different kinds of cells. The ways cells function are similar in all living organisms. **Note:** *Emphasis should be placed on the function and coordination of cell organelles as well as their roles in overall cell function. Specific information about the organelles that need to be addressed at this grade level will be found in the model curriculum.*	**Prior Concepts Related to Cells** **PreK-2:** Living things have specific traits and are made up of a variety of structures. **Grades 3-5:** Organisms are made of parts. **Grade 6 Concepts** The content statements for sixth-grade life science are each partial components of a 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, Modern Cell Theory. It is recommended that the content statements be combined and taught as an integrated unit. For example, the energy needs of cells can be interwoven with the function of mitochondria. Modern Cell Theory states that all living things are made of cells. Cells are the basic unit of structure and function of all living things. Many organisms are single-celled and that one cell carries out all the basic functions of life. Other organisms are multicellular and the cells that form these organisms can be organized at various levels to carry out all the basic functions of life. Different body tissues and organs can be made up of different kinds of cells. The cells in similar tissues and organs in animals are similar. The tissues and organs found in plants differ slightly from similar tissues and organs in animals. Use Modern Cell Theory to exemplify how scientific theories are developed over time. The relationship between structure and function is a crosscutting theme for science and should be explored when investigating the structure and function of cellular organelles. Emphasis is placed on the function and coordination of these components, as well as on the overall cell function. Microscopes, micrographs, models and illustrations using appropriate safety procedures can be used to observe cells from many different types of organisms. The sizes and shapes of cells from single-celled organisms, fungi, plants and animals can be observed and compared. **Future Application of Concepts** **High School:** Details of cellular processes such as photosynthesis, chemosynthesis, cellular respiration, cell division and differentiation 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
Cells			
Analyze and evaluate scientific tradeoffs for use of microbes to produce alternative energy or clean up environmental spills.		Explain how the cellular structures and their functions contribute to the survival of the cell. Consider models or authentic analogies to express understanding. Compare the organelles of a cell to a familiar working system (e.g. school, city, factory). Investigate different types of human cells (e.g., bone, muscle, skin, nerve, blood) using microscopes, models, micrographs, or illustrations. Compare types of cells by looking at different organelles and shapes. Compare cell structure to cell function.	Recognize that cells are the fundamental unit of life. Describe how the structure of specialized cells that form tissues (e.g., xylem, phloem, connective, muscle, nervous) relates to the function that the cells perform. Identify organelles within cells. Emphasis should be placed on those organelles involved in the following cellular functions: transport of materials, energy capture and release, protein building, waste disposal, information feedback and movement. Observe a variety of cells (using microscopes or online pictures/models). Label the visible cellular structures and explain how the structure is related to the function of the organelle in the cell.

Grade 6 continued

LIFE SCIENCE (LS)

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

CONTENT STATEMENT	CONTENT ELABORATION
6.LS.2: All cells come from pre-existing cells. Cells repeatedly divide resulting in more cells and growth and repair in multicellular organisms. **Note:** *This is not a detailed discussion of the phases of mitosis or meiosis. The focus should be on reproduction as a means of transmitting genetic information from one generation to the next, cellular growth and repair.*	**Prior Concepts Related to Species and Reproduction** **PreK-2:** Living things have specific traits and are made up of a variety of structures. **Grades 3-5:** Individual organisms inherit many traits from their parents indicating a reliable way to transfer information from one generation to the next. **Grade 6 Concepts** The content statements for sixth-grade life science are each partial components of a larger concept. The parts have been isolated to call attention to the depth of knowledge required to build to one of biology's important foundational theories: Modern Cell Theory. It is recommended that the content statements be combined and taught as an integrated unit. Modern Cell Theory states that cells come from pre-existing cells. Individual organisms do not live forever. Therefore, reproduction is necessary for the continuation of every species. Traits are passed on to the next generation through reproduction. Single-celled organisms reproduce by processes such as mitosis, budding and binary fission. In this grade, mitosis is explored. In multicellular organisms, mitosis allows cells to multiply for the purpose of growth and repair. All cells contain genetic materials. At this grade level, the genetic material is described as chromosomes. Chromosomes are described as structures in cells that contain genetic material. The chemicals and chemical processes associated with chromosomes are reserved for high school biology. Microscopes, micrographs, models and illustrations can be used to observe cells from different organisms in the process of dividing. It is not appropriate to learn the names of the stages of mitosis. The focus is on observing cells dividing as evidence that cells come from pre-existing cells and genetic material is transmitted from parent cell to daughter cells. The misconception of spontaneous generation can be included in discussions on this topic. The experiments of Redi and Pasteur can be used to explain how evidence can lead to new knowledge, better explanations and spur new technology. **Future Application of Concepts** **Grade 8:** More details about asexual and sexual reproduction will be studied.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Cell division			
	Do an observational study of the growth of an organism from zygote through embryogenesis in both plants and animals.	Model the movement of chromosomes during plant cell division and explain why this process ensures genetic information is passed from one generation to the next. Use the theory that all cells come from pre-existing cells to describe how human bones grow. Research body systems that are involved in human growth. Explain the role mitosis plays in human development (e.g., growth, repair, cancer).	Distinguish between the role of mitosis in single-celled organisms and multicellular organisms.

Grade 6 continued

LIFE SCIENCE (LS)

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

CONTENT STATEMENT

6.LS.3: Cells carry on specific functions that sustain life.

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

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

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

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

CONTENT ELABORATION

Prior Concepts Related to Cellular Functions
PreK-2: Living things have specific traits. Living things require energy, water and a particular temperature range.

Grades 3-5: Organisms are made of structures.

Grade 6 Concepts
The content statements for sixth-grade life science are each partial components of a larger concept. The parts have been isolated to call attention to the depth of knowledge required to build to one of biology's important foundational theories: Modern Cell Theory. In classrooms, it is recommended that the content statements be combined and taught as an integrated unit (e.g., the energy requirements of cells can be interwoven with the function of mitochondria).

Cells have particular structures that are related to their functions. These functions are regulated and controlled (e.g., a cell membrane controls what can enter and leave the cell).

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

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

Future Application of Concepts
Grades 7-8: Photosynthesis and respiration are compared.

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

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	**Demonstrating science knowledge**	**Interpreting and communicating science concepts**	**Recalling accurate science**
Cellular function			
Make bread to investigate yeast under different conditions (e.g., amount or type of sugar, amount or type of flour, temperature). Determine which set of conditions makes the bread least dense.	Conduct an investigation to determine the rate of respiration in yeast cells by varying sugar concentrations or other variables to determine the maximum release of carbon dioxide. **Note:** *Do not conduct a splint test for carbon dioxide.* Investigate osmosis as a way that cell membranes transport materials into/out of a cell. Relate findings to how drugs and other chemicals enter human cells.	Compare various cell types (e.g., muscle, skin, root, stem, leaf) in plants and animals paying close attention to function and structure. Develop models to demonstrate how the various cells of the human immune system function to protect the human body from disease. Explain how different types of blood cells carry out specific functions in the human body. Research technology that is being used to replicate human tissues.	Describe the function of a given cell part. Describe how different organ systems interact to enable complex multicellular organisms to survive.

Grade 6 continued

LIFE SCIENCE (LS)

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

CONTENT STATEMENT

6.LS.4: Living systems at all levels of organization demonstrate the complementary nature of structure and function.

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

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

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

CONTENT ELABORATION

Prior Concepts Related to Structure and Function of Living Things
PreK-2: Living things have specific traits. Living things require energy, water and a particular temperature range.

Grades 3-5: Organisms are made of structures.

Grade 6 Concepts
The content statements for sixth-grade life science are each partial components of a larger concept. The parts have been isolated to call attention to the depth of knowledge required to build to one of biology's important foundational theories: Modern Cell Theory. It is recommended that the content statements be taught as an integrated unit (e.g., levels of organization can be interwoven with the concept of cells as the fundamental unit of life).

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

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

The commonality of life can be investigated through observing tissues, organs, cell structures, systems and symmetry (an approximate balanced distribution of duplicate body parts) for plants and animals. Part of the exploration of the commonality of living systems can include a comparison of cells, types of tissues, organs and organ systems between organisms. View a variety of cells, tissues (e.g., xylem, phloem, connective, muscle, nervous) and organs (e.g., leaf, stem, flower, spore, ganglia, blood vessels, eyes) to compare their similarities and differences. Real-world applications (e.g., the presence of microbes in potable water), new technology and contemporary science can be explored. Inquiry and mathematical relationships should be drawn between cell size and the cell's ability to transport necessary materials into its interior. This link is critical for laying the foundation for the cell cycle in grade 8.

Note: *Living organisms are often organized in classification systems to assist in studying their similarities and differences. These classification systems change as new information emerges. The focus should not be on naming kingdoms rather on comparing internal structures, body systems, body plans and symmetry. Students should focus on how classification is useful as a tool rather than memorizing any particular system.*

Future Application of Concepts
Grade 8: Cellular reproduction is studied.

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

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Levels of organization			
	Conduct a study to compare organisms that are living in an aquatic environment to those living in a terrestrial environment. Hypothesize how the structure can put limits on the size and shape of the organisms in each environment.	Compare a variety of plant and animal cells, tissues (e.g., xylem, phloem, connective, muscle, nervous) and organs (e.g., leaf, stem, flower, spore, ganglia, blood vessels, eyes). Given a particular environment, describe specific internal structures, body plan, and symmetry an organism would need for survival. Create a model or system that shows the progression of the levels of organization from cell to organism in a human. Compare the four major types of tissues (epithelial, connective, nerve and muscle).	Identify general distinctions among the cells of organisms that support classifying some as plants, some as animals and some that do not neatly fit into either group (e.g. fungi, bacteria). Given a group of organisms, classify them based on internal structures, body system and symmetry. Provide justification for the classifications.