Grade 8

INTRODUCTION TO CONTENT STATEMENTS

GRADE BAND THEME: ORDER AND ORGANIZATION

This theme focuses on helping students use scientific inquiry to discover patterns, trends, structures and relationships that may be inferred from simple principles. These principles are related to the properties or interactions within and between systems.

STRANDS

Strand Connections: Systems can be described and understood by analysis of the interaction of their components. Energy, forces and motion combine to change the physical features of Earth. The changes of the physical Earth and the species that have lived on Earth are found in the rock record. For species to continue, reproduction must be successful.

EARTH AND SPACE SCIENCE (ESS)	PHYSICAL SCIENCE (PS)	LIFE SCIENCE (LS)
Topic: Physical Earth This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.	**Topic: Forces and Motion** This topic focuses on forces and motion within, on and around the Earth and within the universe.	**Topic: Species and Reproduction** This topic focuses on continuation of the species.
CONDENSED CONTENT STATEMENTS		
8.ESS.1 The composition and properties of Earth's interior are identified by the behavior of seismic waves. **8.ESS.2** Earth's lithosphere consists of major and minor tectonic plates that move relative to each other. **8.ESS.3** A combination of constructive and destructive geologic processes formed Earth's surface. **8.ESS.4** Evidence of the dynamic changes of Earth's surface through time is found in the geologic record.	**8.PS.1** Objects can experience a force due to an external field such as magnetic, electrostatic or gravitational fields. **8.PS.2** Forces can act to change the motion of objects.	**8.LS.1** Diversity of species, a result of variation of traits, occurs through the process of evolution and extinction over many generations. The fossil records provide evidence that changes have occurred in number and types of species. **8.LS.2** Every organism alive today comes from a long line of ancestors who reproduced successfully every generation. **8.LS.3** The characteristics of an organism are a result of inherited traits received from parent(s).

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 8 continued

EARTH AND SPACE SCIENCE (ESS)

Topic: Physical Earth
This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.

CONTENT STATEMENT

8.ESS.1: The composition and properties of Earth's interior are identified by the behavior of seismic waves.

The refraction and reflection of seismic waves as they move through one type of material to another is used to differentiate the layers of Earth's interior. Earth has a core, a mantle, and a crust. Impacts during planetary formation generated heat.

These impacts converted gravitational potential energy to heat. Earth's core is also able to generate its own thermal energy because of decaying atoms. This continuously releases thermal energy. Thermal energy generated from Earth's core drives convection currents in the asthenosphere.

Note 1: *Radioactive decay is not the focus; this will be discussed in Physical Science and Chemistry.*

Note 2: *At this grade level, analyzing seismograms (e.g., amplitude and lag time) and reading a travel time curve are not the focus. At this grade the properties of seismic waves should be addressed.*

CONTENT ELABORATION

Prior Concepts Related to Earth's Interior
PreK-2: Properties of materials can change due to heating or cooling. Forces change the motion of an object.

Grades 3-5: Matter exists in different states. Heating and cooling can change the state of matter. Heat is a form of energy. Energy can cause motion. Earth's surface is changed in many ways. Light changes direction when it moves from one medium to another; it can be reflected, refracted or absorbed.

Grades 6-7: Matter is made up of atoms. Igneous, metamorphic and sedimentary rocks form in different ways and in different environments. Magma from Earth's interior forms igneous rocks. Position and speed can be measured. Matter and energy can be transferred through Earth's spheres. Energy can be transformed from one form to another. Thermal energy can be transferred through radiation, convection and conduction. Electromagnetic waves transfer energy when they interact with matter. Seismic and oceanic waves are found in physical science, grade 7.

Grade 8 Concepts
It is important to provide background knowledge regarding how scientists know about the structure and composition of the interior of Earth (without being able to see it). Seismic data, graphics, charts, digital displays and cross sections can be used to study Earth's interior. Earth is differentiated into distinct chemical and physical layers. They correspond in the following way [the chemical layer is stated first, followed by the physical layers in parentheses]: the crust (upper lithosphere), the mantle (lower lithosphere, asthenosphere, mesosphere) and the core (outer and inner).

The refraction and reflection of seismic waves, as they travel through the lithosphere to the inner core, is used to identify the different physical layers of Earth's interior. The thicknesses of each layer of Earth can vary and be transitional, depending on composition, density, temperature and pressure, rather than uniform and distinct as often depicted in textbooks.

Earth and other planets in the solar system formed as heavier elements (primarily iron and nickel) coalesced in their centers and formed planetary cores. The less dense, lighter elements (potassium and sodium for example) remained closer to the planetary surface. This is planetary differentiation, a process through which distinct layers with characteristic chemical and/or physical properties are formed. A major period of planetary differentiation occurred in our solar system approximately 4.6 billion years ago (College Board Standards for College Success, 2009). There are three main sources of heat in Earth's interior: primordial heat left over from planetary accretion, the decay of radioactive elements and friction as materials move within the Earth.

In addition to the composition of Earth's interior, the history of the formation of Earth and relationships among energy transfer, energy transformation and convection currents within the mantle and crust are essential in understanding sources of energy.

Future Application of Concepts

High School: Waves (all types), gravitational energy, energy transformation and transfer and radioactivity are studied in greater detail. In addition, Earth's formation and the formation of the solar system are examined as the formation of the universe 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

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
Formation of Earth			
		Compare Earth's chemical layers with the physical layers. Include their properties and how they interact. Narrate a journey to Earth's core. Features of the journey could include mode of transportation, length of time in each layer, sights seen and other aspects. Use a density column to illustrate how Earth's layers differentiated during formation.	Create a model that identifies Earth's layers.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Seismic waves			
Evaluate the best locations for seismographs. Design a seismograph that can be used in a less ideal location (e.g., underwater, areas prone to landslides, local earthquake zone areas, wetlands, etc.).		Interpret characteristics of Earth's interior using a variety of resources (e.g., seismic data, maps, diagrams, models, charts, cross sections).[1] Show how seismic data is used to determine the composition of the interior of Earth. Gather evidence that Earth is not homogeneous by comparing a seismic record section to predicted arrivals from a homogeneous Earth model. [2]	Demonstrate the different seismic wave motions and speeds using a Slinky®. Create a graphic organizer comparing p- and s-waves.

[1] Iris: Shadow Zone
[2] Iris: Earth's Layers

Grade 8 continued

EARTH AND SPACE SCIENCE (ESS)

Topic: Physical Earth
This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.

CONTENT STATEMENT

8.ESS.2: Earth's lithosphere consists of major and minor tectonic plates that move relative to each other.

Historical data and observations such as fossil distribution, paleomagnetism, continental drift and seafloor spreading contributed to the theory of plate tectonics. The rigid tectonic plates move with the molten rock and magma beneath them in the upper mantle.

Convection currents in the asthenosphere cause movements of the lithospheric plates. The energy that forms convection currents comes from deep within the Earth.

There are three main types of plate boundaries: divergent, convergent and transform. Each type of boundary results in specific motion and causes events (such as earthquakes or volcanic activity) or features (such as mountains or trenches) that are indicative of the type of boundary.

CONTENT ELABORATION

Prior Concepts Related to Forces, Movement and Igneous Environments
PreK-2: Properties of materials can change. Pushing and pulling can affect the motion of an object.

Grades 3-5: Forces change the motion of an object. Rocks have specific characteristics. Heat is a form of energy. Energy can be transferred and transformed. Earth's surface has specific characteristics. Gravitational force and magnetism are studied.

Grades 6-7: Rocks have characteristics that are related to the environment in which they form. Thermal energy is a measure of the motion of the atoms and molecules in a substance. Energy can be transferred, transformed and is conserved. Thermal energy can be transferred through radiation, convection and conduction.

Grade 8 Concepts
Historical data related to the modern-day theory of plate tectonics, which led to theories of continental drift (Wegener), convection theory (Holmes) and seafloor spreading (Hess, Deitz) is introduced. The data supporting these theories include paleontological data, paleoclimate data, paleomagnetic data and the continental "puzzle-like-fit" noticed as early as Magellan and by other mapmakers and explorers. Contemporary data is introduced, including seismic data, GPS/GIS data (documenting plate movement and rates of movement), robotic studies of the sea floor and further exploration of Earth's interior.

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

Volcanic activity, earthquakes, tsunamis, geysers, hot springs, faults, oceanic vents, island arcs, hot spots and rift valleys are included in the identification of plates and plate boundaries. Plate boundary identification (convergent, divergent, transform) is based on the resulting features or events. The focus is on the cause of plate movement, the type and direction of plate movement and the result of the plate movement, not on memorizing plate names.

Future Application of Concepts
High School: Thermal energy, gravitational energy, radioactive decay and energy transfer are studied in more depth. In Physical Geology, further studies of plate tectonics, seismology and volcanism are found.

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
Historical data			
	Investigate, using magnetic data from new technology and the rock record, the pattern of reversing magnetism within Earth's core. Generate a chart or graph to represent findings. Using historical data, predict a time range for when the next reversal could occur. Discuss what impact the reversal could have for humans.	Use rock and fossil data to recreate the position of the continents at various points in history. Graph the age of the Hawaiian Islands and other seamounts and their distance from Kilauea to determine the speed and direction the Pacific Plate is moving due to plate tectonics.[1] Model seafloor spreading at mid-ocean ridges. Map the age of the seafloor.	Describe the historical evidence for plate tectonics, including the early observations, discoveries and ideas that combined to eventually lead to the modern theory of plate tectonics. Make a timeline to show the development of our current theory of plate tectonics. Differentiate between plate tectonics and continental drift.
Mechanisms for movement			
Research and determine the effectiveness of current warning systems in tectonically active regions (e.g., the design of devices and their locations). Suggest changes or improvements.	Research the implications of plate tectonics and produce an artifact to answer one or more of the following questions: 1. What consequences might be encountered if the continents joined together again (Pangaea Ultima)? 2. What will Earth look like in 250 million years? How will the distribution of living things change?	Measure the difference in density between granite and basalt; analyze the role of density in lithospheric interaction. Using a world map, mark the locations of earthquakes and volcanoes that are recorded each week for one month (or longer). Use a different color or pattern so that earthquakes and volcanoes can be differentiated. Outline the boundaries of where the concentrations are	Determine types of plate boundaries based on geologic data (e.g., location and magnitude of earthquakes and volcanoes, elevation and age of ocean crust). Explain the mechanism for plate movement (convection currents in the asthenosphere). Recognize that oceanic crust is more dense and thinner than continental crust.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
	3. What fossils might paleontologists find in the future that would help them map locations of Earth's continents during the 21st century? 4. Where is the best place to live to avoid natural disasters caused by tectonic plates? Research the most recent measurements of North America. Using this data and the movement of North America throughout geologic time, predict where North America will be in 600 million years or more. Create a model to demonstrate that movement.	located. Compare/contrast this map with a map of plate boundaries. Ask: What types of boundaries are found in the volcano areas? What types are found in earthquake areas?	Observe the depths of earthquake foci for different types of plate boundaries.[2] Model movements at different plate boundaries (convergent, divergent and transform) and lithospheric interactions (continental-continental, continental-oceanic and oceanic-oceanic) using manipulatives.

[1]Hawaiian Island Age- Hot Spot Activity
[2]Earthquake Browser Iris IEB

Grade 8 continued

EARTH AND SPACE SCIENCE (ESS)

Topic: Physical Earth
This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.

CONTENT STATEMENT	CONTENT ELABORATION
8.ESS.3: A combination of constructive and destructive geologic processes formed Earth's surface. Earth's surface is formed from a variety of different geologic processes, including but not limited to plate tectonics.	**Prior Concepts Related to Earth's Surface** **PreK-2:** Water can be found in many forms and locations. Wind is air in motion. **Grades 3-5:** Characteristics of rocks and soil, weathering, deposition, erosion, landforms, mass movement and weather events (e.g., flooding) are studied. **Grades 6-7:** Igneous, metamorphic and sedimentary rock formation, interactions between Earth systems and patterns of erosion and deposition are studied. **Grade 8 Concepts** The interactions between the hydrosphere and lithosphere are studied as they relate to erosional events (e.g., flooding, mass movement). The characteristics of rocks and soil, climate, location, topography and geologic process are studied. Distinguishing between major geologic processes (e.g., tectonic activity, erosion, deposition) and the resulting feature on the surface of Earth is the focus of this content statement. It is important to build on what was included in the elementary grades (recognizing features), enabling students to describe conditions for formation. Topographic, physical and aerial maps, cross-sections, field trips and virtual settings are methods of demonstrating the structure and formation of each type of feature. Technology (e.g., remote sensing, satellite data, LANDSAT) can be used to access real-time photographs and graphics related to landforms and features. Factors that affect the patterns and features associated with streams and floodplains (e.g., discharge rates, gradients, velocity, erosion, deposition), glaciers (e.g., moraines, outwash, tills, erratics, kettles, eskers), tectonic activity (includes the features listed in the previous content statement), coastlines, flooding and deserts should be studied. **Future Application of Concepts** **High School:** Gravitational forces and movement of matter are explored. In Physical Geology, glaciation, sedimentation, stream evolution, seismology, volcanism, bathymetry and further information about weathering, erosion and deposition are included.

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
Erosion and deposition			
Research and develop a regional solution to minimize the impacts of mass movement events (e.g. flooding, landslides, mudflows, sinkholes, rockfalls).	Devise a stream table and use it to model factors (e.g., glacial activity, gradient, discharge rate, load) and test rates of erosion and deposition in a stream meander over time.	Use current event articles to find examples of gradual and catastrophic destructive processes (e.g., creep vs. landslide).	Label sets of images as erosion or deposition. Identify examples of destructive geologic processes (e.g., flooding, mass wasting, volcanic activity, glacial movement, earthquakes, tsunamis.
Topography			
Research a specific area with active geologic processes or events. Develop a plan to harness the available energy (e.g., heat from magma, water movement) from the geologic activity. Build a working model using specific data, including from the geologic record, about the location. Use the model to evaluate the efficiency of the type of energy chosen.	Design a model of karst topography enabling a 3-D view of a cave or sinkhole. Research the processes that must occur to form karst topography.	Using a topographic map or simulation, explain the processes that created glacial features (e.g., moraines, outwash, fills, erratics, kettles, eskers). Use *Google Earth* to identify the location of features created by glaciers. Compare to a topographic map. Make a claim about the role of glaciers in reshaping the physical landscape of Ohio. Support that claim with topographic and/or surface geologic evidence and reasoning.	Identify features of a surface using a topographic map. Compare topographic features between locations of glaciated and unglaciated Ohio.

Grade 8 continued

EARTH AND SPACE SCIENCE (ESS)

Topic: Physical Earth
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CONTENT STATEMENT

8.ESS.4: Evidence of the dynamic changes of Earth's surface through time is found in the geologic record.

Earth is approximately 4.6 billion years old. Earth history is based on observations of the geologic record and the understanding that processes observed at present day are similar to those that occurred in the past (uniformitarianism). There are different methods to determine relative and absolute age of some rock layers in the geologic record. Within a sequence of undisturbed sedimentary rocks, the oldest rocks are at the bottom (superposition). The geologic record can help identify past environmental and climate conditions.

CONTENT ELABORATION

Prior Concepts Related to Rocks and Fossils
PreK-2: Some living things that once lived on Earth no longer exist because their needs were not met.

Grades 3-5: Rocks have characteristics and form in different ways. Earth's surface changes. Most types of organisms that have lived on Earth no longer exist. Fossils provide a point of comparison between the types of organisms that lived long ago and those living today. Rocks can change size and shape due to weathering. Ice can physically remove and carry rock, soil and sediment.

Grades 6-7: Igneous, metamorphic and sedimentary rocks form in different ways. Each type of rock can provide information about the environment in which it was formed.

Grade 8 Concepts
Representations of the age of Earth should include a graphic demonstration of the immensity of geologic time, as this is a very difficult concept to grasp. The different methods used to determine the age of Earth are an important factor in this concept. In elementary grades, fossils are used to compare what once lived to what lives now, but the concept of Earth's age and the age of the fossils were not included (the concept of billions or millions of years was not age-appropriate). In grade 8, the concept of index fossils is a way to build toward understanding relative dating. Superposition, cross-cutting relationships and index fossils play an important role in determining relative age. Radiometric dating plays an important role in absolute age. The inclusion of new advances and studies is important in learning about the geologic record.

Uniformitarianism can be an important key in understanding how scientists have interpreted the environmental conditions that existed throughout Earth's history. Fossil evidence also can indicate specific environments and climate conditions that help interpret the geologic record. Environmental and climate conditions can also be documented through the cryosphere as seen through ice cores. Relating Earth's climate history to present-day climate issues should include evidence from ice core sampling as well as evidence from the geologic record.

Using actual data to generate geologic maps of local or statewide formations can connect to the real world. Field studies or geologic research (virtual/digital) can help identify local formations and interpret the environment that existed at the time they were formed. Analyzing and interpreting the data to draw conclusions about geologic history is an important part of this content statement.

Future Application of Concepts
High School: The age of Earth is further explored through learning about the evolution and extinction of species throughout Earth's history. In Physical Geology, the interpretations of sections of the rock record and geologic time periods 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
Uniformitarianism			
	Analyze ice core data to reconstruct a region's past environmental and climate conditions. Identify patterns in ice core data to hypothesize the relative composition of present-day and future ice cores. Conduct a local field study or research the geological record of Ohio (virtual/digital) using the past geologic record and make a claim as to how events in the past shaped present-day Ohio. Provide evidence to support your claim.[1] Use the Ohio geologic record to explain why certain industries (e.g., salt, gravel, gas/oil) are prevalent in Ohio. Investigations can be done virtually or through local field studies (e.g., quarries, mines).	Design a gallery walk of different rock types (e.g., coal, sandstone, limestone, shale, granite, basalt) to illustrate different industrial uses. Share with a lower grade.	Explain the Theory of Uniformitarianism including information about James Hutton and Siccar Point, Scotland.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Rock record			
		Arrange rock layers based on index fossils. Determine which radiometric dating method would be best to use for a given fossil.	Recognize the immensity of the geologic time scale.

[1] ODNR: Ohio Geologic Record Data

Grade 8 continued

PHYSICAL SCIENCE (PS)

Topic: Forces and Motion
This topic focuses on forces and motion within, on and around the Earth and within the universe.

CONTENT STATEMENT	CONTENT ELABORATION
8.PS.1: Objects can experience a force due to an external field such as magnetic, electrostatic, or gravitational fields. Magnetic, electrical and gravitational forces can act at a distance.	**Prior Concepts Related to Forces** **PreK-2:** Forces are introduced as pushes and pulls that can change the motion of objects. Magnetic, gravitational and electrical forces act without touching. **Grades 3-5:** The amount of change in movement of an object is based on the mass of the object and the amount of force exerted. The speed of an object is defined and calculated. **Grades 6-7:** An object's motion can be described by its speed and the direction in which it is moving. An object's position and speed can be measured and graphed as a function of time. **Grade 8 Concepts** This content statement involves a basic introduction to the field model. A field model can be used to explain how two objects can exert forces on each other without touching. Details about the field model are not required other than the idea that a field is a concept that is used to understand forces that act at a distance. An object is thought to have a region of influence, called a field, surrounding it. When a second object with an appropriate property is placed in this region, the field exerts a force on and can cause changes in the motion of the object. In grade 8, content will focus on connecting and organizing prior knowledge using the field model. Three types of fields should be investigated: gravitational, electric and magnetic. Every object with mass exerts a gravitational force on every other object with mass. These forces are hard to detect unless at least one of the objects is very massive (e.g., sun, planets). The gravitational force increases with the mass of the objects, decreases rapidly with increasing distance and points toward the center of objects. Weight is the force that a mass experiences in a gravitational field. Weight is often confused with mass. Weight is proportional to mass, but depends upon the gravitational field at a particular location. An object will have the same mass when it is on the moon as it does on Earth. However, the weight (force of gravity) will be different at these two locations. Electrostatic fields exist around objects with a net charge. If a second object with a net charge is placed in the field, the two objects experience electric forces that can attract or repel them, depending on the sign of the charges involved. Magnetic fields exist around magnetic objects. If a second magnetic object is placed in the field, the two objects experience magnetic forces that can attract or repel them, depending on the orientation of the objects involved. Magnetic field lines can be seen when iron filings are sprinkled around a magnet.

Electricity is related to magnetism. In some circumstances, magnetic fields can produce electrical currents in conductors. Electric currents produce magnetic fields. Electromagnets are temporary magnets that lose their magnetism when the electric current is turned off. Building an electromagnet to investigate magnetic properties and fields can demonstrate this concept.

Note 1: *Magnetic poles are often confused with electric charges. It is important to emphasize the differences.*

Note 2: *Mathematics is not used to describe fields at this level.*

Future Application of Concepts
High School: The strength of the force between two charges is calculated using Coulomb's Law. Electromagnetic induction is applied to generators and motors. DC circuits 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
Fields of non-contact forces			
		Use a graphic organizer to compare the interactions of two charged objects, two magnets and two uncharged objects with mass.	Differentiate between electric charges and magnetic poles. Given a simple interaction between two objects that are not touching (e.g., a ball falling to the ground, a magnet and a steel cabinet, hair and a brush experiencing static), identify the objects involved in the interaction and give the direction of the force on each object.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Magnetic fields			
Design and build a prototype of a device that uses the force of attraction to lift and release an object of a certain mass to assist in the sorting of materials at a recycling center or salvage center.	Design an experiment to test factors that affect the strength of an electromagnet (e.g. number and tightness of coils, size and type of core, current and voltage of circuit, wire type). Investigate the direction of the magnetic field around a variety of objects using compasses, iron filings and/or magnetic field sensors. Compare the relative strengths of magnets by comparing the load they can lift (e.g., paperclips). Use data collected to compare magnets of different shapes.	Build a simple electromagnet to investigate how an electric current generates a magnetic field. Observe and document the patterns of magnetic fields around pairs of magnets (include examples of repulsion and attraction).	Explain that the magnetic force exerted on other objects located in a magnetic field increases as the strength of the magnet increases and decreases as the distance from the magnet increases.
Gravitational fields			
	Plan an investigation to determine how the mass or the distance between objects interacting at a distance impacts the amount of gravitational potential energy that is stored in the system.	Use an example to illustrate that objects with mass create gravitational fields and are attracted to each other with forces that are directly proportional to their mass. Use the field model to explain why an apple will fall toward Earth.	Differentiate between the concepts of mass and weight. Explain how mass and distance affect the magnitude of the gravitational force between two objects.
Electrostatic fields			
Design a device, such as a homemade electroscope, that can detect the presence of an electric charge. Design and build a game board that moves an object using electric charges (e.g., obstacle course, hockey).	Design an investigation or use a simulation to determine the relationship between either distance and force or charge and force for two charges. Analyze the data to determine patterns and trends. Formulate a conclusion about the relationship.	Construct a visual representation of the forces on objects as the type of electric charge and/or distance between them changes.	Identify the behavior of charged objects in an electric field (include examples of repulsion and attraction). Create labeled diagrams and descriptions to communicate how various charged and uncharged objects react in the presence of an electric field.

Grade 8 continued

PHYSICAL SCIENCE (PS)

Topic: Forces and Motion
This topic focuses on forces and motion within, on and around the Earth and within the universe.

CONTENT STATEMENT

8.PS.2: Forces can act to change the motion of objects.

The motion of an object is always measured with respect to a reference point.

Forces can be added. The net force on an object is the sum of all of the forces acting on the object.

If there is a nonzero net force acting on an object, its speed and/or direction will change.

Kinetic friction and drag are forces that act in a direction opposite the relative motion of objects.

CONTENT ELABORATION

Prior Concepts Related to Forces
PreK-2: Forces are introduced as pushes and pulls that can change the motion of objects. Forces are required to change the motion of an object. A greater force on a given object results in a greater change of motion.

Grades 3-5: The amount of change in movement of an object is based on the mass of the object and the amount of force exerted. Balanced and unbalanced forces are introduced.

Grades 6-7: An object's motion can be described by its speed and the direction in which it is moving. An object's position and speed can be measured and its position can be graphed as a function of time.

Grade 8 Concepts
Motion can be described in different ways by different observers (e.g., a pencil held in someone's hand may appear to be at rest, but to an observer in a car speeding by, the pencil may appear to be moving).

When multiple forces act on an object, their combined effort is what influences the object's motion (speed and direction). Forces can cancel to a net force of zero if they are equal in strength and act in opposite directions. Such forces are said to be balanced. If all forces are balanced, the object will maintain its current motion (both speed and direction). This means if the object is stationary, it will remain stationary. If the object is moving, it will continue moving in the same direction and at the same speed. When the net force is nonzero, the forces are unbalanced and the object's motion will change.

The forces acting on an object can be modeled by a force diagram. Forces are represented by arrows drawn on an isolated picture of the object. The direction of each arrow shows the direction of the force. The length of each arrow represents the magnitude of the force. The effect of the net force on the motion of an object can be predicted from a force diagram. The direction and relative size of the net force can be identified from force diagrams involving multiple forces. Diagrams with forces in both the horizontal and vertical directions can be considered. At this grade level, there should be unbalanced forces in only one of these dimensions. Forces can also act to change the direction of objects. If a force on an object acts toward a single center, the object's path may curve into an orbit around the center.

Friction is a force that opposes sliding between two surfaces. For surfaces that are sliding relative to each other, the force on an object always points in the direction opposite the relative motion of the object. This force is known as kinetic friction. Drag is a force that opposes the motion of an object when a solid object moves through a fluid (e.g., gas, liquid). Kinetic friction and drag affect the motion of objects and may even cause moving objects to slow to a stop unless another force is exerted in the direction of motion. A lack of understanding of friction can lead to the misconception that objects require a sustained force to continue moving. Experimentation with objects that have limited friction (e.g., a puck on an air hockey table, dry ice on a surface) can address this misconception. In grade 8, friction will only be calculated from force diagrams. Static friction, as well as the equations for static and kinetic friction, are found in Physics.

Future Application of Concepts
High School: Newton's second law will be developed quantitatively and situations will be explored mathematically.

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
Frame of reference			
		Describe the motion of an object based on multiple reference points.	Recognize that the motion of objects is determined with respect to a fixed reference point.
Effects of forces acting on objects			
Design and build a simple model, using Newton's first law of motion, to demonstrate the benefits of seatbelts. Use the model to compare the effectiveness of shoulder and lap belts vs. lap belts alone.	Explore the effect of multiple forces on the motion of objects (e.g., cars or marbles and ramps, student tug-o-war, spring launchers with different force amounts). Investigate how opposing forces affect motion in a system consisting of two weights connected by a string hanging over a pulley.	Predict the combined effect (e.g., speed up, slow down, turn left, turn right) of several forces on an object at rest or an object moving in a straight line.	Create a force diagram to illustrate the combined forces acting on an object. Explain how the force of gravity can be acting on a book at rest on a table and yet the book does not move. Recognize that free fall results from the gravitational attraction between Earth and an object.
Friction			
Improve the design of a component or system to reduce/increase the effects of friction on a moving object (e.g., tire, fishing reel, ski, skateboard, bicycle).	Investigate the relationship between the type of surface and the effects of kinetic friction on moving objects (e.g., experiment with moving an object across various surfaces). Determine what type of force is needed to get a moving puck on an air hockey table to slow down, speed up or move in a circle.	Identify situations where friction is beneficial, detrimental or both.	Explain that friction opposes the motion of objects.

Grade 8 continued

LIFE SCIENCE (LS)

Topic: Species and Reproduction
This topic focuses on continuation of the species.

CONTENT STATEMENT

8.LS.1: Diversity of species, a result of variation of traits, occurs through the process of evolution and extinction over many generations. The fossil records provide evidence that changes have occurred in number and types of species.

Fossils provide important evidence of how life and environmental conditions have changed.

Changes in environmental conditions can affect how beneficial a trait will be for the survival and reproductive success of an organism or an entire species.

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

Note: *Population genetics and the ability to use statistic mathematics to predict changes in a gene pool are reserved for high school Biology.*

CONTENT ELABORATION

Prior Concepts Related to Species and Reproduction
PreK-2: Living things have physical traits that enable them to live in different environments. Some kinds of individuals that once lived on Earth have completely disappeared, although they may be something like others that are alive today.

Grades 3-5: Fossils provide a point of comparison between the types of organisms that lived long ago and those existing today.

Grades 6-7: In a biome, the number, growth and survival of organisms and populations depend on biotic and abiotic conditions.

Grade 8 Concepts
The fossil record documents the variation in a species that may have resulted from changes in the environment. The fossil record is contained within the geologic record (ESS grade 8). Combining data from the geologic record and the fossil record, Earth's living history can be interpreted. Data and evidence from the fossil record can be used to further develop the concepts of extinction, biodiversity and the diversity of species. The term "transitional form" is used to describe intermediate organisms between ancestral forms and their descendants. Some examples of transitional forms were fossilized and found in the fossil record. Other transitional forms are missing from the fossil record.

Evidence from the geologic and fossil record can be used to infer what the environment was like at the time of deposition. The variations that exist in organisms can accumulate over many generations, so organisms can be very different in appearance and behavior from their distant ancestors. Diversity can result from sexual reproduction. The sorting and combination of genes result in different genetic combinations, which allow offspring to be similar to, yet different from, their parents and each other (this statement connects to the grade 8 Life Science content statement on reproduction and Mendelian Genetics). These variations may allow for survival of individuals when the environment changes. Diversity in a species increases the likelihood that some individuals will have characteristics suitable to survive and reproduce when conditions change.

Note: *Molecular clocks are not appropriate at this grade level.*

Future Application of Concepts
High School: Diversification of species is explored in more depth.

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
Survival advantages			
		Compare the ability of organisms to survive under different environmental conditions. Investigate structural differences in past and present organisms that have enabled some species to survive while others have become extinct due to sudden or gradual environmental changes (e.g., peppered moths, crayfish fossils found in Antarctica). Work with fossils that demonstrate bilateral symmetry. Investigate ways having bilateral symmetry can be an advantage. Consider how having bilateral symmetry benefits humans.	
Fossils as environmental evidence			
		Use evidence from geologic and fossil records to infer what the environment was like at the time a specific organism lived. Use a model to identify the relative ages of various fossils or rock layers using index fossils.	Define and give examples of index fossils. Map the multiple mass extinction events that have occurred throughout Earth's history. Explain why 99% of all species that have ever existed on Earth are extinct.

Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Natural selection and biodiversity			
Develop a policy to address the increasing rates of antibiotic or herbicide-resistant infections. Consider the perspectives of various stakeholders (e.g., farmers, government agencies, doctors, land managers).	Conduct a field study on a specific population of plants or animals in a local area. Examine members of that population and record variations in physical characteristics that can be seen (e.g., height, coloration, number of flowers). Predict which traits are more beneficial for survival in the population's current environment. Predict what variations may result in higher survival rates should the environment change (e.g., became warmer, colder, wetter, windier).	Examine organisms that are found in a variety of environments and others that have very specific habitats to determine which have the greater chance of survival when the environment changes. Compare adaptations that allow an organism to survive under different environmental conditions (e.g., specialists like panda bears and their dependency on bamboo or generalists like the raccoon). Use manipulatives to model how selection pressures influence a population. Analyze how the populations change due to these pressures. Graph data that indicates how the biodiversity in a particular biome or continent has changed over time.	Describe how to determine the relative age of fossils found in sedimentary rock. Explain why variation within a population can be advantageous for a population of organisms.

Grade 8 continued

LIFE SCIENCE (LS)

Topic: Species and Reproduction
This topic focuses on continuation of the species.

CONTENT STATEMENT

8.LS.2: Every organism alive today comes from a long line of ancestors who reproduced successfully every generation.

Reproduction is the transfer of genetic information from one generation to the next. It can occur with mixing of genes from two individuals (sexual reproduction). It can occur with the transfer of genes from one individual to the next generation (asexual reproduction). The ability to reproduce defines living things.

CONTENT ELABORATION

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

Grades 6-7: Modern Cell Theory states cells come from preexisting cells.

Grade 8 Concepts
Organisms reproduce either sexually or asexually. Some organisms are capable of both. In asexual reproduction, all genes come from a single parent, resulting in offspring genetically identical to their parent. Mitosis was introduced in grade 6. At this grade level, the end products of mitotic and meiotic cell divisions are compared as they relate to asexual and sexual reproduction. Mitosis and meiosis are addressed in preparation for the study of Mendelian genetics in 8.LS.3.

In sexual reproduction, a single specialized cell from a female (egg) merges with a specialized cell from a male (sperm). Half of the nuclear genes come from each parent. The fertilized cell, carrying genetic information from each parent, multiplies forming the genetically complete organism. Each cell of an organism contains the same genetic information. As opposed to asexual reproduction, sexual reproduction results in offspring with new combinations of traits which may increase or decrease their chances for survival.

Future Application of Concepts
High School: Genetic variation in traits among offspring is a result of the movement of chromosomes crossing over, independent assortment and recombination during gamete formation. The implications of mutation during gamete formation 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
Asexual and sexual reproduction			
Research the use of cloning in agriculture. Identify a problem that was solved by cloning and possible benefits and issues that can occur because of the use of cloning in that example, supporting your ideas with scientific evidence.	Examine offspring in plants that are produced sexually. Note and record variations that appear. Determine how the variations may help an organism to survive if the environment should change (e.g., warmer or cooler temperatures, increase or decrease in precipitation).	Use microscopes, web-based video or simulations to observe microscopic organisms that reproduce asexually and/or sexually (e.g., paramecium, hydra, aphids, yeast, planaria). Compare sexual and asexual reproduction and discuss the advantages and disadvantages. Compare the processes and end products of mitosis and meiosis. Compare the genetic diversity of the daughter cells from these processes. Explain why genetic variation is a survival advantage. Recognize that human egg and sperm are produced by meiosis. Explain how this is beneficial to humans.	Predict the number of chromosomes in a body cell when given the number in a gamete. Predict the number of chromosomes in a gamete when given the number in a body cell. Explain how the number of chromosomes in a daughter cell is related to the number of chromosomes in the parent cell for mitosis and meiosis. Describe the features of sexual and asexual reproduction related to the transfer of genetic information from parent to offspring.

Grade 8 continued

LIFE SCIENCE (LS)

Topic: Species and Reproduction
This topic focuses on continuation of the species.

CONTENT STATEMENT

8.LS.3: The characteristics of an organism are a result of inherited traits received from parent(s).

Expression of all traits is determined by genes and environmental factors to varying degrees. Many genes influence more than one trait, and many traits are influenced by more than one gene.

During reproduction, genetic information (DNA) is transmitted between parent and offspring. In asexual reproduction, the lone parent contributes DNA to the offspring. In sexual reproduction, both parents contribute DNA to the offspring.

Note 1: *The focus should be the link between DNA and traits without being explicit about the mechanisms involved.*

Note 2: *The ways in which bacteria reproduce is beyond the scope of this content statement.*

Note 3: *The molecular structure of DNA is not appropriate at this grade level.*

CONTENT ELABORATION

Prior Concepts Related to Species and Reproduction
PreK-2: Offspring tend to look like their parents.

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

Grades 6-7: Modern Cell Theory states cells come from preexisting cells.

Grade 8 Concepts
The traits of one or two parents are passed on to the next generation through reproduction. Traits are determined by instructions encoded in deoxyribonucleic acid (DNA), which forms genes. Genes have different forms called alleles. The principles of Mendelian genetics are introduced by reviewing Mendel's work. Mendel's two laws provide the theoretical base for future study of modern genetics. Mendel's first law, the Law of Segregation, and his second law, the Law of Independent Assortment, should be demonstrated and illustrated in a variety of organisms.

The concepts of dominant and recessive genes are appropriate at this grade level. Codominant traits such as roan color in horses and cows may be useful to provide further validation of the theory and to help dispel some misconceptions. Pedigree analysis is appropriate for this grade level when limited to dominant, recessive or codominance of one trait. The Law of Independent Assortment should only be explored in simple cases of dominant and recessive traits. Incomplete dominance is not suggested for this grade level to help avoid the misconception of "blending of traits." Codominance is encouraged because both traits are expressed in the resulting offspring. Dihybrid crosses and sex-linked traits also are reserved for high school.

A long-term investigation to analyze and compare characteristics passed on from parent to offspring through sexual and asexual reproduction can be conducted. These investigations can lead to questions about the phenotypes that appear in the resulting generations and what they infer about genotypes of the offspring.

Future Application of Concepts
High School: The details and importance of gamete formation, the structure of DNA and modern genetics are studied.

EXPECTATIONS FOR LEARNING

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Designing technological/engineering solutions using science concepts	Demonstrating science knowledge	Interpreting and communicating science concepts	Recalling accurate science
Inheritance of genetic information			
Research artificial selection (e.g., genetic modification, animal husbandry, gene therapy). Select one practice and determine how that practice has changed the way humans influence the inheritance of desired traits in organisms. Discuss and evaluate the ethics of genetic modification and artificial selection (e.g., drought-resistant crops, designer dogs)	Design and implement an investigation to predict the genotypes and phenotypes of offspring between plants of known heritage (e.g., Wisconsin Fast Plants™, Arabidopsis).	Predict the genotypic and phenotypic ratios for a monohybrid cross with Mendelian dominance and codominance patterns through at least two generations. Determine allele combinations that make it possible for traits to skip generations. Conduct a forensic investigation to explore complete dominance (Rh factors) and codominance (ABO blood type) inheritance patterns.	Describe how DNA, genes, chromosomes and inherited traits are connected. Select a genetic condition and show its inheritance pattern through multiple generations on a pedigree or other graphic representation Select a variety of genetic conditions to explore autosomal dominant, autosomal recessive and codominant inheritance patterns.