

Test Specifications: Grade 8 Science

Introduction

The Grade 8 Science Test Specifications provide an overview of the structure and content of the test. This overview includes a description of the test design as well as information on the types of items that will appear on the test. A test blueprint is included, composed of a table identifying the range and distribution of items and points, grouped into various categories. The specifications also provide specific guidelines for the development of all items used for the Grade 8 Science test. This document is intended to be a resource not only for item writers and test designers, but for Ohio educators and other stakeholders who are interested in a deeper understanding of the test.

General Description of the Grade 8 Science Test

In 2010 Ohio adopted new rigorous academic content standards for Grade 8 Science. A model curriculum based on these new standards was adopted in 2011.

An achievement assessment that aligns to the new standards and model curriculum is mandated by Ohio Revised Code 3301.079. The assessment will be administered as a two-part test, in an online format, to measure progress toward the standards and to provide information to teachers and administrators. Test results are reported back to schools by June 30th.

Test Design

The structure of the Grade 8 Science Test will consist of two parts that will be given near the end of the year. There are two parts in order to provide flexibility in test administration for school districts. Both parts of the test are fixed forms that are administered in an online format. In addition to technology-enhanced items, the test will also contain constructed-response items that require the student to enter a response into the computer interface. The sequence and timing of the administration of Part 1 and Part 2 is determined by the district. After the student has completed both parts of the test, his or her scores will be combined to yield a comprehensive view of the student's progress.

Test Blueprint

The following test blueprint shows the content statements assessed in each reporting category, and the distribution of points.

Grade 8 Science Test Blueprint

Reporting Category	Topic	Points	Total Points on Form	Approximate Percent of Test
Earth Science	The composition and properties of Earth's interior are identified by the behavior of seismic waves.	21 - 23	54 - 56	38% - 43%
	Earth's crust consists of major and minor tectonic plates that move relative to each other.			
	A combination of constructive and destructive geologic processes formed Earth's surface.			
	Evidence of dynamic changes of Earth's surface through time is found in the geologic record			
Life Science	Diversity of species occurs through gradual processes over many generations. Fossil records provide evidence that changes have occurred in number and types of species.	16 - 18	54 - 56	29% - 33%
	Reproduction is necessary for the continuation of every species.			
	The characteristics of an organism are a result of inherited traits received from parent(s).			
Physical Science	Forces between objects act when the objects are in direct contact or when they are not touching.	16 - 18	54 - 56	29% - 33%
	Forces have magnitude and direction.			
	There are different types of potential energy.			

Description of Item and Stimulus Types

Item Types

Item types are divided into four categories: multiple-choice, enhanced selected-response, machine-scored constructed response and human-scored.

A **multiple-choice** item may consist of the following:

- a brief statement that orients students to the context of the question;
- a stimulus (document, data table, graphic, etc.) on which the question is based;
- a question or prompt;
- a set of answer choices (most often four) that allows students to select one option in response to the question.

An **enhanced selected-response** item may consist of the following:

- a brief statement that orients students to the context of the question;
- a stimulus (document, data table, graphic, etc.) on which the question is based;
- a question or prompt;
- a set of answer choices that allows students to select multiple options in response to one question, matching options together to classify information, selecting evidence supporting an initial answer choice, or a very structured graphic-response interface.
- Enhanced selected-response items allow students to demonstrate deeper understanding than multiple-choice items by having multiple parts or multiple correct answers.

A **machine-scored constructed-response** item may consist of the following:

- a brief statement that orients students to the context of the question;
- a stimulus (document, data table, graphic, etc.) on which the question is based;
- a prompt;
- a graphic-response, text/numeric entry, or simulation interface.
 - A graphic-response interface allows students to manipulate objects to create a response to the question. The graphic-response interface may be a map, a chart or graph, a picture, a diagram, or an interactive simulation on which the students must draw or position objects correctly.
- Machine-scored constructed-response items offer the students a great degree of freedom to create their own response. These items allow students to demonstrate deeper understanding than multiple-choice or enhanced selected-response items by requiring students to construct their own response instead of selecting their answer

from a given set of choices. These items are scored based on an item-specific rubric.

A **human-scored constructed-response** item may consist of the following:

- a brief statement that orients students to the context of the questions;
- one or more stimuli (documents, graphics, data displays, etc.) to which the questions refer;
- a question or set of questions that require a detailed written response or responses. The responses are scored by trained scorers according to a rubric or set of rubrics that address multiple dimensions in students' work.

Stimulus Types

A **simulation** stimulus consists of the following:

- An interactive graphic interface that presents a set of interactive stimulus materials or simulates an investigative experiment, physical situation, or an aspect of the inquiry process. The graphics may be static or contain animation. Information is displayed in the form of dynamic illustrations or maps, statistical tables, texts, charts, or graphs. Data "inputs" can be adjusted by the students, depending on the requirements of the scenario or the associated items, and the graphics adjust themselves to account for the new inputs.
- When a simulation is used as part of a task, the simulation is accompanied by one or more items of various types. The simulation functions as an interactive stimulus that provides information for the student to reflect on, analyze or synthesize with other knowledge into a cognitively demanding set of answers. This can be used to simulate an aspect of scientific inquiry.

Other stimulus types associated with discrete items or tasks may include:

- Document excerpts and other texts
- Photographs and illustrations
- Graphs
- Charts
- Data tables
- Maps
- Timelines

Item Specifications: Grade 8 Science

Earth and Space Science (ESS)

Topic: Physical Earth

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

Content Statement: The composition and properties of Earth’s interior are identified by the behavior of seismic waves.

The refraction and reflection of seismic waves as they move through one type of material to another is used to differentiate the layers of Earth’s interior. Earth has an inner and outer core, an upper and lower mantle, and a crust.

The formation of the planet generated heat from gravitational energy and the decay of radioactive elements, which are still present today. Heat released from Earth’s core drives convection currents throughout the mantle and the crust.

Note: The thicknesses of each layer of Earth can vary and be transitional, rather than uniform and distinct as often depicted in textbooks.

Content Elaboration:

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

Earth and other planets in the solar system formed as heavier elements coalesced in their centers. Planetary differentiation is a process in which more dense materials of a planet sink to the center, while less dense materials stay on the surface. A major period of planetary differentiation occurred approximately 4.6 billion years ago (College Board Standards for College Success, 2009).

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

Content Limits:

- Matter and energy (thermal, radioactive, seismic) are transferred through the interior of Earth;
- Behavior and properties of seismic waves;
- Mechanisms and techniques to indirectly study the composition of Earth's interior;
- Interpretation of seismic wave speed data relative to depth within Earth or state of matter;
- Radioactive decay (only as it relates to energy in Earth's interior);
- History of formation, including planetary differentiation based on density of materials;
- Role of convection currents in energy and matter transfer between the mantle and the crust;
- Composition and thickness of Earth layers vary and are transitional as opposed to uniform and distinct.

Do Not Assess:

- Different states of matter;
- Effect of heat on states of matter;
- Definitions and characteristics of P-waves and S-waves;
- Physical properties and behaviors of waves not directly related to the study of Earth's interior;
- Mechanisms of the formation of the solar system;
- The speed of seismic waves within specific substances (e.g. the speed in basalt);
- The actual thickness of Earth's layers;
- Features of instruments that measure seismic activity;
- The details and processes of radioactive decay.

Stimulus Attributes:

- Diagrams of Earth's interior;
- Graphs or data representing seismic waves (e.g., seismic profile);
- Advancing technologies that impact the study of Earth's interior;
- Cross sections of Earth and other planets;
- Graphs or tables of temperature vs. depth from Earth's surface;
- Diagrams/pictures showing energy transfer by radiation, convection and conduction as it applies to Earth's interior.

Response Attributes:

Response options may include, but are not limited to, the following:

- Completing or interpreting diagrams showing energy transfer (convection, conduction, radiation) within the Earth's interior;

- Interpreting seismic wave data to determine changes in density or state of matter in Earth's interior;
- Predicting the direction and/or rate of the transfer of energy or matter within Earth based on data;
- Given data or diagrams, drawing conclusions about the formation of Earth (e.g., radioactive decay, differentiation);
- Evaluating or interpreting information gathered from technological advances relating to Earth's interior;
- Given data, developing and justifying conclusions about the formation of Earth and/or Earth's interior;
- Evaluating composition and cross-sections data of Earth and other planets to make and justify conclusions about the formation and history of each planet.

Distractors may include, but are not limited to, the following:

- Common misconceptions:
 - Layers of Earth are uniform.
 - Seismic waves only relate to earthquakes.
 - Planetary differentiation was recent.
 - The interior of Earth has a uniform temperature.
 - Seismic waves travel at uniform speeds.

Earth and Space Science (ESS)

Topic: Physical Earth

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

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

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

Convection currents in the crust and upper mantle cause the movement of the plates. The energy that forms convection currents comes from deep within the Earth.

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

Content Elaboration:

The historical data related to the present plate tectonic theory must include continental "puzzle-like-fit" noticed as early as Magellan and by other mapmakers and explorers, paleontological data, paleoclimate data, paleomagnetic data, continental drift (Wegener), convection theory (Holmes) and sea floor spreading (Hess, Deitz). Contemporary data must be introduced, including seismic data, GPS/GIS data (documenting plate movement and rates of movement), robotic studies of the sea floor and further exploration of Earth's interior.

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

Volcanic activity, earthquakes, tsunamis, geysers, hot springs, faults, oceanic vents, island arcs, hot spots and rift valleys should all be included in the identification of plates and plate boundaries. Plate boundary identification (converging, diverging, transform) must be based on the resulting features or events. The focus must be on the cause of

plate movement, the type and direction of plate movement and the result of the plate movement, not on memorizing plate names.

Content Limits:

- Evidence for the theory of plate tectonics (including historical data);
- Contemporary research and discoveries that measure plate movement;
- Movement of tectonic plates caused by convection currents in the crust and upper mantle;
- Movement of tectonic plates at boundaries as it relates to plate density;
- Types and characteristics of tectonic plate boundaries and the resulting features or events.

Do Not Assess:

- Characteristics of rocks;
- Numeric values of the rate of plate movement;
- Thermal energy and/or energy transfer;
- Identifying tectonic plate, site, or boundary names (e.g., Pacific plate, North American plate, San Andreas Fault, Mariana Trench);
- Identifying scientists by name or contribution.

Stimulus Attributes:

- Maps or data to support evidence of continental drift, sea-floor spreading, and plate tectonics;
- Diagrams/pictures/maps/cross-sections showing tectonic plate boundaries and/or the history of plate movement;
- Diagrams/pictures/maps/cross-sections showing tectonic events or features;
- Tables/graphs showing data of tectonic activity (e.g., incidents of earthquakes over time, rate of volcanic eruptions, GPS/GIS).

Response Attributes:

Response options may include, but are not limited to, the following:

- Interpreting data or visual representations relating to tectonic plate boundaries or the history of plate movement;
- Differentiating between characteristics of plate tectonics and continental drift;
- Explaining or predicting geological features caused by plate boundaries;
- Categorizing tectonic plate boundaries based on features or events;
- Given data about tectonic plates, predicting type of boundary or movement;

- Using evidence to support continental drift, sea-floor spreading and plate tectonics;
- Using evidence to support and justify specific conclusions involving continental drift, sea-floor spreading, and plate tectonics;
- Use data from diagrams/data/maps to explain and justify a conclusion about how movement at plate boundaries causes geological features and/or events.

Distractors may include, but are not limited to, the following:

- Common misconceptions:
 - All tectonic plates move at the same rate.
 - Earthquakes and volcanoes only occur at plate boundaries or at specific geographical locations.
 - Plates and continents are equivalent.
 - Continents float.
 - Continental drift and plate tectonics are equivalent.

Earth and Space Science (ESS)

Topic: Physical Earth

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

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

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

Note: The introduction of Earth's surface is found in ESS grade 4.

Content Elaboration:

The interactions between the hydrosphere and lithosphere are studied as they relate to erosional events (e.g., flooding, mass wasting). The characteristics of rocks and soil, the climate, location, topography and geologic process are studied.

Distinguishing between major geologic processes (e.g., tectonic activity, erosion, deposition) and the resulting feature on the surface of Earth is the focus of this content statement. It is important to build on what was included in the elementary grades (recognizing features), enabling students to describe conditions for formation. Topographic, physical and aerial maps, cross-sections, field trips and virtual settings are methods of demonstrating the structure and formation of each type of feature. The use of technology (remote sensing, satellite data, LANDSAT) can be used to access real-time photographs and graphics related to landforms and features.

Factors that affect the patterns and features associated with streams and floodplains (e.g., discharge rates, gradients, velocity, erosion, deposition), glaciers (e.g., moraines, outwash, tills, erratic, kettles, eskers), tectonic activity (should include the features listed in the content statement above), coastlines, flooding and deserts should be studied.

Content Limits:

Note: Geologic features related to tectonic activity are assessed in the previous content statement.

- Characteristics of rocks and soil, climate, location, and topography as they relate to constructive and destructive processes between the hydrosphere and lithosphere;
- Major geologic processes that form specific features on the surface of Earth (tectonic activity, erosion, deposition);

- Factors (e.g., topography, climate, soil and rock characteristics) that affect the surface patterns associated with streams, floodplains, glaciers, coastlines, flooding and deserts.

Do Not Assess:

- Specific types of weathering or forms of deposition, stream evolution, seismology, volcanics, and/or bathymetry;
- Numerical values for rates of erosion, water flow, deposition, etc.;
- Specific names of landforms or faults (e.g., moraines, San Andreas Fault).

Stimulus Attributes:

- Pictures/diagrams/cross-sections/maps (including topographical maps) of geologic features produced by tectonic activity, erosion, and/or deposition;
- Tables reporting characteristics of various rock and soil types as they relate to the formation of land forms;
- Tables/graphs/data showing stream discharge rate, velocity, volume, and/or seasonal depth;
- Tables/graphs/data showing glacial velocity, movement, and thickness;
- Tables/graphs/data showing precipitation type and amount, slope, graduation, rock/soil type, geomorphic data, and ground water velocity;
- Pictures/diagrams/maps showing changes in waterways over time.

Response Attributes:

Response options may include, but are not limited to, the following:

- Interpreting pictures or diagrams of geologic features to determine the process of formation;
- Predicting the effect of rock and soil types (e.g., sandy, clay), location, topography, and climate on erosion and deposition;
- Using a map to indicate where specific landforms would be located due to constructive or destructive processes over time;
- Completing a diagram based on data that shows how constructive or destructive processes will affect the lithosphere over time;
- Identifying the processes that cause various types of surface features to form (e.g., rivers, streams, deserts, coastlines);
- Describing the processes that cause various types of surface features to form (e.g., rivers, streams, deserts, coastlines);
- Using data or a diagram, justify a conclusion dealing with how constructive or destructive processes affect the lithosphere in specific scenarios;
- Using evidence from aerial photographs and/or topographical maps to generate and justify a conclusion about how specific land features were formed.

Distractors may include, but are not limited to, the following:

- Common misconceptions:
 - Erosion and deposition are similar.
 - Weathering and erosion are equivalent.
 - Erosion and deposition are always fast or always slow.

Earth and Space Science (ESS)

Topic: Physical Earth

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

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

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

Note: Environmental and climate conditions also can be documented through the cryosphere as seen through ice cores.

Content Elaboration:

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

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

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

the formation. Analyzing and interpreting the data to draw conclusions about geologic history is an important part of this content statement.

Note: This content is closely connected to LS grade 8 content pertaining to diversity of species as documented in the fossil record, tracing changes evident in the fossil record and relating this content to evolution.

Content Limits:

- Connection between presence of specific rock types, rock features, or fossils and environmental conditions at the time of formation (e.g., rocks with ripple marks and moving water or basalt and volcanic activity);
- The concept of uniformitarianism, which can be used to interpret past environmental conditions by comparing to current conditions;
- Relative age, which is determined by the Law of Superposition, index fossils, and crosscutting relationships;
- Absolute age, which is determined by radiometric dating;
- Relative age and absolute age, which provide evidence that leads to the understanding of geologic time;
- Climate change as documented by the geologic record and ice cores.

Do Not Assess:

- Fossils as a point of comparison between the types of organisms that lived long ago and those living today;
- Names of fossils;
- Specific evolution and extinction events throughout Earth's history;
- The names and dates of geologic time periods (e.g., epochs, eras, the Jurassic period);
- Half-life determination and the mechanics of absolute dating.

Stimulus Attributes:

- Pictures/diagrams/cross-sections of bedrock with and without intrusions folding and overturning showing actual or hypothetical rock records;
- Surface/bedrock maps of Ohio;
- Pictures/diagrams of geologic columns and/or glacial cores;
- Geologic timelines with other pictures/diagrams/cross-sections of bedrock.

Response Attributes:

Response options may include, but are not limited to, the following:

- Interpreting relative age and/or environmental conditions from cross sections, pictures, or diagrams showing geologic columns and/or glacial cores;

- Comparing and contrast relative age and/or environmental conditions of two or more geologic columns and/or glacial cores;
- Given data, determining relative age and explaining how it can be determined by the Law of Superposition, index fossils, and crosscutting;
- Comparing absolute and relative age;
- Given a data-rich scenario, formulate conclusions about relative ages and justify with evidence;
- Analyzing a cross-section of the rock record to generate conclusions about past environmental conditions and explaining how evidence supports these conclusions;
- Using evidence from a geologic column to make conclusions about Earth's geologic history and make comparisons between the past and present.

Distractors may include, but are not limited to, the following:

- Common misconceptions:
 - Climate change and global warming are equivalent.
 - Climate and weather are equivalent.
 - Humans and dinosaurs coexisted.
 - Human timescales and geologic timescales are equivalent.
 - The present environment is the same as the past environment.

Life Science (LS)

Topic: Species and Reproduction

This topic focuses on continuation of the species.

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

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

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

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

Note: Population genetics and the ability to use statistical mathematics to predict changes in a gene pool are reserved for grade 10.

Content Elaboration:

The fossil record documents the variation in a species that may have resulted from changes in the environment. The fossil record is contained within the geologic record (ESS grade 8). Combining data from the geologic record and the fossil record, Earth's living history can be interpreted. Data and evidence from the fossil record must be used to develop further the concepts of extinction, biodiversity and the diversity of species.

Diversity can result from sexual reproduction. The sorting and combination of genes results in different genetic combinations, which allow offspring to be similar to, yet different from, their parents and each other. (This statement must be connected to the grade 8 Life Science content statement on reproduction and Mendelian Genetics.) These variations may allow for survival of individuals when the environment changes. Diversity in a species increases the likelihood that some individuals will have characteristics suitable to survive under changed conditions.

Evidence from geologic and fossil records can be used to infer what the environment was like at the time of deposition. The variations that exist in organisms can accumulate over many generations, so organisms can be very different in appearance and behavior from their distant ancestors.

Note 1: Molecular clocks are not appropriate at this grade level.

Note 2: The term “transitional form” should be used to describe parts of the fossil record that are incomplete.

Content Limits:

- Diversity in a species may provide benefits through changing environmental conditions;
- Geologic and fossil records as evidence for past environmental conditions;
- The fossil record as evidence for biodiversity, diversity within a species, and the fact that the majority of species that have lived on Earth are now extinct.

Do Not Assess:

- Fossils as a point of comparison between the types of organisms that lived long ago and those existing today;
- Population genetics and the ability to use statistical mathematics to predict changes in a gene pool;
- Identifying biotic and abiotic conditions in an ecosystem;
- The terms “natural selection” and “evolution” (concepts can be assessed but not names or specific mechanisms);
- Interpreting geologic profiles;
- Examples related to bacteria (antibiotic resistance).

Stimulus Attributes:

- Tables and graphs showing changes in population traits/characteristics over time as the environment changes;
- Scenarios showing diversity between populations in isolation (e.g., Isle Royale Moose, Galapagos Islands) and other populations (Yellowstone moose);
- Diagrams or charts displaying the fossil record.

Response Attributes

Response options may include, but are not limited to, the following:

- Describing or predicting how genetic variation (e.g., beak structure, coloration) affects the survival or extinction of a species when environmental conditions change gradually or suddenly;
- Inferring past environmental changes based on evidence from the fossil record;
- Evaluating graphs showing population data related to environmental changes;
- Using evidence from a data-rich scenario to formulate and justify conclusions about how genetic variation (e.g., beak structure, coloration) affected the survival or extinction of a species when environmental conditions have changed;

- Evaluating data from fossil records to make and justify a conclusion about environmental changes.

Distractors may include, but are not limited to, the following)

- Common misconceptions:
 - Changes in a population only happen quickly within a single generation.
 - Individual organisms genetically adapt as a response to changing environmental conditions.
 - Extinction only occurs in animal populations.
 - Extinctions are only caused by catastrophic events.
 - Extinctions are rare.

Life Science (LS)

Topic: Species and Reproduction

This topic focuses on continuation of the species.

Content Statement: Reproduction is necessary for the continuation of every species.

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

Content Elaboration:

An individual organism does not live forever. Reproduction is necessary for the continuation of every species. Most organisms reproduce either sexually or asexually. Some organisms are capable of both. In asexual reproduction, all genes come from a single parent, which usually means the offspring are genetically identical to their parent, allowing genetic continuity. Mitosis was investigated in grade 6. The end products of mitotic and meiotic cell divisions are compared as they relate to asexual and sexual reproduction. It is important that both mitosis and meiosis are addressed in preparation for future study of Mendelian genetics and embryology.

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

Content Limits:

- Mitosis and meiosis are processes by which genetic material is copied and divided in asexual or sexual reproduction;
- Mitosis produces daughter cells that are genetically identical to the parent cell;
- Meiosis produces sex cells containing half the genetic material of the parent cell;
- Sexual reproduction involves the combining of sex cells, which results in an organism with genetic material from the parent(s);
- Asexual reproduction occurs with the transfer of genes from one individual to the next generation and results in an offspring with identical genetic material;
- Advantages and disadvantages of sexual and asexual reproduction for the continuation of the species.

Do Not Assess:

- Details and importance of gamete formation (spermatogenesis, oogenesis);
- Stages and rate of mitosis and meiosis;
- Modern cell theory that cells originate from pre-existing cells;
- Specific types of asexual reproduction such as budding;
- Examples of organisms that reproduce asexually or sexually.

Stimulus Attributes:

- Simple life cycles showing sexual and asexual reproduction;
- Diagrams showing parent and daughter cells with the same and differing numbers of chromosomes;
- Real world scenarios illustrating advantages and disadvantages of sexual and asexual reproduction.

Response Attributes:

Response options may include, but are not limited to, the following:

- Completing diagrams showing the end products of mitosis or meiosis;
- Relating the end products of mitosis or meiosis to sexual and asexual reproduction;
- Comparing end products of sexual and asexual reproduction with an emphasis on their advantages and disadvantages in relation to the continuation of the species;
- Interpreting data from real-world scenarios or experiments showing outcomes (e.g., survival and reproduction rates) of sexual and asexual reproduction under varying environmental conditions;
- Comparing the end products of mitosis or meiosis and how they relate to sexual and asexual reproduction;
- Evaluating sexual and asexual reproduction and the differences in how they affect the likelihood of survival through environmental changes;
- Interpreting and explaining data from real world scenarios or experiments showing outcomes (e.g., survival and reproduction rates) of sexual and asexual reproduction under varying environmental conditions.

Distractors may include, but are not limited to, the following:

- Common Misconceptions:
 - Sexual reproduction produces traits that are always beneficial and never harmful.
 - Organisms reproduce only sexually or asexually.
 - Sexual reproduction requires two individuals.
 - Plants can't reproduce sexually.
 - One reproductive process is better than another.

Life Science (LS)

Topic: Species and Reproduction

This topic focuses on continuation of the species.

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

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

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

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

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

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

Content Elaboration:

The traits of one or two parents are passed on to the next generation through reproduction. Traits are determined by instructions encoded in deoxyribonucleic acid (DNA), which forms genes. Genes have different forms called alleles. Introduce the principles of Mendelian genetics by reviewing Mendel's work. Mendel's two laws provide the theoretical base for future study of modern genetics. Mendel's first law, the Law of Segregation, and his second law, the Law of Independent Assortment, should be demonstrated and illustrated in a variety of organisms. The concepts of dominant and recessive genes are appropriate at this grade level. Co-dominant 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 co-dominance of one trait. The Law of Independent Assortment should only be explored in simple cases of dominance and recessive traits. Chi-square and dihybrid crosses are reserved for high school.

Conduct a long-term investigation to analyze and compare characteristics passed on from parent to offspring through sexual and asexual reproduction. Ask questions about the phenotypes that appear in the resulting generations and what they infer about genotypes of the offspring.

Note: Incomplete dominance is not suggested for this grade level to help avoid the misconception of “blending of traits.” Codominance is encouraged because both traits are expressed in the resulting offspring.

Content Limits:

- Genetic traits are determined by information encoded in DNA passed on from parent to offspring;
- Principles of Mendelian genetics, Law of Segregation, and Law of Independent Assortment (concepts not terms);
- Punnett squares and pedigrees using dominant, recessive, and co-dominant traits.

Do Not Assess:

- Details of gamete formation;
- The molecular function and structure of DNA;
- Names of Mendel’s laws;
- Advanced genetics concepts and techniques (e.g., chi square test, dihybrid cross, incomplete dominance, sex-linked inheritance);
- Mechanisms of bacterial reproduction;
- Examples of human genetic traits (e.g., eye color, hair color, diseases);
- The terms “heterozygous”, “homozygous”, “purebred”, “hybrid”.

Stimulus Attributes:

- Pedigrees and Punnett squares;
- Diagrams/pictures showing expression of a phenotype in a sample;
- Tables or graphs showing phenotype data in a population;
- Diagrams/pictures showing genotypes and/or phenotypes of parents and offspring.

Response Attributes:

Response options may include, but are not limited to, the following:

- Determining possible genotypes and their probabilities of occurring in offspring from a cross;
- Analyzing data showing the frequency of phenotypes in a population;
- Completing pedigrees illustrating relationships between phenotypes and genotypes;
- Completing Punnett squares to illustrate probabilities of offspring related to genotype/phenotype;
- Analyzing pedigrees to determine whether a trait is dominant/recessive/co-dominant;
- Designing an experiment to identify genotypes in plants.

Distractors may include, but are not limited to, the following:

- Common misconceptions:
 - The results of a Punnett square are exact predictions of resulting offspring.
 - Offspring receive all their genetic traits from the same sex parent.
 - Offspring always show the same traits as one parent.
 - Parents' genetic traits blend equally in offspring.
 - All behavioral traits are genetic or no behavior traits are genetic.
 - Every trait is determined by only two genes.
 - The male parent's genes are always dominant.
 - Some traits come from one parent, and others come from the other parent.

Physical Science (PS)

Topic: Forces and Motion

This topic focuses on forces and motion within, on and around the Earth and within the universe.

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

Magnetic, electrical and gravitational forces can act at a distance.

Note: Direct contact forces were addressed in the elementary grades.

Content Elaboration:

A field model can be used to explain how two objects can exert forces on each other without touching. An object is thought to have a region of influence, called a field, surrounding it. When a second object with an appropriate property is placed in this region, the field exerts a force on and can cause changes in the motion of the object.

Electric fields exist around objects with charge. If a second object with charge is placed in the field, the two objects experience electric forces that can attract or repel them, depending on the charges involved. Electric force weakens rapidly with increasing distance.

Magnetic fields exist around magnetic objects. If a second magnetic object is placed in the field, the two objects experience magnetic forces that can attract or repel them, depending on the objects involved. Magnetic force weakens rapidly with increasing distance. Magnetic field lines can be seen when iron filings are sprinkled around a magnet.

Gravitational fields exist around objects with mass. If a second object with mass is placed in the field, the two objects experience attractive gravitational forces toward each other. Gravitational force weakens rapidly with increasing distance.

Every object exerts a gravitational force on every other object with mass. These forces are hard to detect unless at least one of the objects is very massive (e.g., sun, planets). The gravitational force increases with the mass of the objects, decreases rapidly with increasing distance and points toward the center of objects. Weight is gravitational force and is often confused with mass. Weight is proportional to mass, but depends upon the gravitational field at a particular location. An object will have the same mass when it is on the moon as it does on Earth. However, the weight (force of gravity) will be different at these two locations.

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

Generators convert mechanical energy into electrical energy and are used to produce electrical energy in power plants. Electric motors convert electrical energy into mechanical energy. Motors are in blenders and washing machines. Both motors and generators have magnets (or electromagnets) and a coil of wire that creates its own magnetic field when an electric current flows through it.

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

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

Note 3: This content statement involves a basic introduction to the field model. Details about the field model are not required other than the idea that a field is a concept that is used to understand forces that act at a distance.

Content Limits:

- Basic understanding of gravitational, electric, and magnetic fields;
- Behavior of objects with mass, charge and/or magnetic properties in gravitational, electric, or magnetic fields;
- The effect of distance on field strength (electric, magnetic and gravitational);
- Differences between mass and weight (gravitational force);
- Relationship between electric currents and magnetic fields;
- Generators and motors utilize the relationship between electric currents and magnetic fields to transform energy between electrical and mechanical.

Do Not Assess:

- Field diagrams (other than iron filings sprinkled over magnets);
- Identifying types of forces acting at a distance;
- Direct contact forces;
- The amount of change in movement of an object is based on the mass of the object and the amount of force exerted;
- Calculations involving field theory, Newton's universal law of gravitation, Coulomb's Law, or any mathematical laws of magnetism;
- Details about the field model beyond a field is a concept that is used to understand forces that act at a distance;
- Physical mechanisms (e.g., induction) or calculations of electromagnetic induction as applied to generators and motors;
- Electric circuits.

Stimulus Attributes:

- Drawings/pictures showing 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);
- Drawings/pictures of a magnet and iron filings;
- Drawings/pictures of an object in an electric field (e.g., electron);
- Drawings/pictures of an object in a magnetic field (e.g., compass);
- Drawings/pictures of an object in a gravitational field (e.g., falling mass, satellite in orbit);
- Basic drawings/pictures of motors, generators, or electromagnets.

Response Attributes:

Response options may include, but are not limited to, the following:

- Comparing the properties of gravitational, electric, and magnetic fields;
- Comparing the properties of fields and forces;
- Interpreting the magnetic field from drawings/pictures of a magnet and iron filings;
- Determining what types of objects (e.g., massive, electric, magnetic) will experience a force in a given field;
- Relating the force on an object to its distance from the source of a field (e.g., masses, charged objects);
- Using diagrams of motors, generators, or electromagnets, relating how the relationship between current and magnetic field is utilized to make them work;
- Designing an experiment to assess how objects would behave in a(n) electric, magnetic or gravitational field;
- Explaining at a basic level how generators, motors, or electromagnets work (based on transformation of energy and the relationship between current and magnetic field).

Distractors may include, but are not limited to, the following:

- Common misconceptions:
 - Mass and weight are equivalent.
 - Force is a property of an object that can be “used up”.
 - Only moving objects can exert a force.
 - There is no gravity in space.
 - Large objects create a greater force than small objects.
 - Magnetic poles are confused with electric charges.

Physical Science (PS)

Topic: Forces and Motion

This topic focuses on forces and motion within, on and around the Earth and within the universe.

Content Statement: Forces have magnitude and direction.

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

Forces can be added. The net force on an object is the sum of all of the forces acting on the object. The net force acting on an object can change the object's direction and/or speed.

When the net force is greater than zero, the object's speed and/or direction will change.

When the net force is zero, the object remains at rest or continues to move at a constant speed in a straight line.

Content Elaboration:

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

A force is described by its strength (magnitude) and in what direction it is acting. Many forces can act on a single object simultaneously. The forces acting on an object can be represented by arrows drawn on an isolated picture of the object (a force diagram). The direction of each arrow shows the direction of push or pull. When many forces act on an object, their combined effect is what influences the motion of that object. The sum of all the forces acting on an object depends not only on how strong the forces are, but also in what directions they act. Forces can cancel to a net force of zero if they are equal in strength and act in opposite directions. Such forces are said to be balanced. If all forces are balanced by equal forces in the opposite direction, the object will maintain its current motion (both speed and direction). This means if the object is stationary, it will remain stationary. If the object is moving, it will continue moving in the same direction and at the same speed. Such qualitative, intuitive understandings and descriptions of inertia must be developed through inquiry activities.

Kinetic friction is a force that occurs when two objects in contact interact by sliding past one another. Drag is a force that opposes the motion of an object when an object moves through a fluid (e.g., gas, liquid). Kinetic friction and drag affect the motion of objects and may even cause moving objects to slow to a stop unless another force is exerted in the direction of motion. This phenomenon leads to the misconception that objects require a sustained force to continue moving. Experimentation with objects that

have limited friction (e.g., a puck on an air hockey table, dry ice on a surface) can address the misconception that objects with a net force of zero naturally slow down.

If the forces are not balanced, the object's motion will change, either by speeding up, slowing down or changing direction. Qualitative, intuitive understandings of the influence of unbalanced forces on objects must be developed through inquiry investigations.

Note 1: The concept of fields for objects that exert forces without touching is introduced at this grade level.

Note 2: The content description states that there will be acceleration when “the net force is greater than zero.” When positive and negative values are used to represent the direction of forces, this statement will need to be expanded. Any nonzero net force, including a negative net force, also may result in a change in speed or direction (acceleration).

Content Limits:

- The effect of multiple forces (in the same or opposite directions) on the motion of an object, including kinetic friction and drag;
- Force/Free-body diagrams;
- The relativity of motion depending on the observer.

Do Not Assess:

- Newton's Laws, referenced by name or number;
- Identifying types of force;
- Inertia;
- A single force acting on an object;
- Forces in two dimensions unless the net force in one of the dimensions is zero;
- Problems involving mathematics and calculations (although proportional reasoning may be assessed);
- The term “acceleration.”

Stimulus Attributes:

- Simple force/free body diagrams;
- Tables or data describing forces on an object or motion;
- Scenarios involving relative motion.

Response Attributes:

Response options may include, but are not limited to, the following:

- Completing or analyze simple force/free body diagrams;
- Given a scenario about relative motion, describing the motion of an object from a specific reference point;

- Given a scenario involving balanced or unbalanced forces, explaining or predicting changes in motion;
- Designing an experiment to test the effect of multiple forces on the motion of an object.

Distractors may include, but are not limited to, the following:

- Common misconceptions:
 - Objects in motion require a force.
 - Objects at rest have no forces acting on them.

Physical Science (PS)

Topic: Forces and Motion

This topic focuses on forces and motion within, on and around the Earth and within the universe.

Content Statement: There are different types of potential energy.

Gravitational potential energy changes in a system as the masses or relative positions of objects are changed.

Objects can have elastic potential energy due to their compression or chemical potential energy due to the nature and arrangement of the atoms that make up the object.

Content Elaboration:

Gravitational potential energy is associated with the mass of an object and its height above a reference point (e.g., above ground level, above floor level). A change in the height of an object is evidence that the gravitational potential energy has changed.

Elastic potential energy is associated with how much an elastic object has been stretched or compressed and how difficult such a compression or stretch is. A change in the amount of compression or stretch of an elastic object is evidence that the elastic potential energy has changed.

Chemical potential energy is associated with the position and arrangement of the atoms within substances. Rearranging atoms into new positions to form new substances (chemical reaction) is evidence that the chemical potential energy has most likely changed. The energy transferred when a chemical system undergoes a reaction is often thermal energy.

Electrical potential energy is associated with the position of electrically charged objects relative to each other and the amount of charge they have. A change in the position of charged particles relative to each other is evidence of a change in electrical potential energy.

Magnetic potential energy is associated with the position of magnetic objects relative to each other.

The different types of potential energy must be explored through experimentation and investigation that include the relationship of energy transfer and springs, magnets or static electricity.

Note: Potential energy is often taught as “stored” energy. If the word “stored” means that it is kept by the object and not given away to another object, then kinetic energy also can be classified as “stored” energy. A rocket moving at constant speed through space has kinetic energy and is not transferring any of this energy to another object.

Content Limits:

- Gravitational potential energy (near the surface of Earth) depends on the mass and height of an object (Grade 6 discusses height change only);
- Elastic potential energy as a function of position of an elastic object (i.e. compression or stretch of spring or bungee cord);
- Chemical potential energy depends on the position and arrangement of atoms, and chemical reactions often involve the transformation between thermal and chemical potential energy;
- Electric potential energy depends on the position and magnitude of charges;
- Magnetic potential energy depends on the position of magnetic objects relative to each other.

Do Not Assess:

- Definition of energy as the ability to cause motion or create change;
- Identifying forms of energy (e.g., heat, electrical energy, light, sound, and magnetic energy);
- Processes within organisms that require energy;
- Electric potential;
- Mathematical calculations of the conservation of energy, or types of potential energy;
- Spring constant;
- Potential energy as “stored energy.”

Stimulus Attributes:

- Tables/graphs reporting potential energy relative to distance between objects;
- Drawings/pictures showing various systems containing potential energy (e.g., coiled spring);
- Scenario involving chemical reactions and heat.

Response Attributes:

Response options may include, but are not limited to, the following:

- Using data from a real-world scenario, completing graphs relating potential energy to position and mass;
- Comparing the different types of potential energy and how they change;

- Describing various forms of potential energy within a system in terms of the positions of the objects involved (e.g., elastic potential energy in a spring, electrical potential energy associated with charges);
- Making and justifying conclusions about an experiment that studies the relationship between position and potential energy in a system.

Distractors may include, but are not limited to, the following:

- Common misconceptions:
 - Potential energy is only gravitational, and only depends on an object's height.
 - Only potential energy is "stored."
 - Energy and force are equivalent.
 - Energy is a tangible thing.