ITEM SPECIFICATIONS
8TH GRADE
OAKS SCIENCE TEST

2014 Oregon Science Standards (NGSS)

OREGON DEPARTMENT OF EDUCATION

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Introduction

This document presents *cluster specifications* for use with the Next Generation Science Standards (NGSS). These standards are based on the Framework for K-12 Science Education. The present document is not intended to replace the standards, but rather to present guidelines for the development of items and item clusters used to measure those standards.

The remainder of this section provides a very brief introduction to the standards and the framework, an overview of the design and intent of the item clusters, and a description of the cluster specifications that follow. The bulk of the document is composed of cluster specifications, organized by grade and standard.

Background on the framework and standards

The Framework for K-12 Science Education is organized around three core dimensions of scientific understanding. The standards are derived from these same dimensions:

Disciplinary Core Ideas

The fundamental ideas that are necessary for understanding a given science discipline. The core ideas all have broad importance within or across science or engineering disciplines, provide a key tool for understanding or investigating complex ideas and solving problems, relate to societal or personal concerns, and can be taught over multiple grade levels at progressive levels of depth and complexity.

Science and Engineering Practices

The practices are what students **do** to make sense of phenomena. They are both a set of skills and a set of knowledge to be internalized. The SEPs (Science and Engineering Practices) reflect the major practices that scientists and engineers use to investigate the world and design and build systems.

Cross-Cutting Concepts

These are concepts that hold true across the natural and engineered world. Students can use them to make connections across seemingly disparate disciplines or situations, connect new learning to prior experiences, and more deeply engage with material across the other dimensions. The NGSS requires that students explicitly use their understanding of the CCCs to make sense of phenomena or solve problems.

There is substantial overlap between and among the three dimensions

For example, the cross-cutting concepts are echoed in many of the disciplinary core ideas. The core ideas are often closely intertwined with the practices. This overlap reflects the nature of science itself. For example, we often come to understand and communicate causal relationships by employing models to make sense of observations. Even within a dimension, overlap exists. Quantifying characteristics of phenomena is important in developing an understanding of them, so employing computational and mathematical thinking in the construction and use of models is a very common scientific practice, and one of the cross-cutting concepts suggests that scientists often infer causality by observing patterns. In short, the dimensions are not orthogonal.

The framework envisions effective science education as occurring at the intersection of these interwoven dimensions: students learn science by doing science; applying the practices through the lens of the cross-cutting concepts to investigate phenomena that relate to the content of the disciplinary core ideas.

Item clusters

Each item cluster is designed to engage the examinee in a grade-appropriate, meaningful scientific activity aligned to a specific standard.

Each cluster begins with a phenomenon, an observable fact or design problem that engages student interest and can be explained, modeled, investigated, or designed using the knowledge and skill described by the standard in question.

What it means to be observable varies across practices. For example, a phenomenon for a performance expectation exercising the a*nalyze data* practice may be observable through regularities in a data set, while standards related to the *development and use of models* might be something that can be watched, seen, felt, smelled, or heard.

What it means to be observable also varies across grade levels. For example, elementary-level phenomena are very concrete and directly observable. At the high school level, an observation of the natural world may be more abstract: for example, "observing" changes in the chemical composition of cells through the observation of macroscopic results of those changes on organism physiology, or through the measurement of system- or organ-level indications.

Content limits refine the intent of the performance expectations and *provide limits* on what may be asked of items in the cluster to structure the student activity. The content limits also reflect the disciplinary core ideas learning progressions that are present in the K-12 Framework for Science Education.

The task or goal should be explicitly stated in the stimulus or the first item in the cluster: statements such as "In the questions that follow, you will develop a model that will allow you to identify moons of Jupiter," or "In the questions below, you will complete a model to describe the processes that lead to the steam coming out of the teapot."

Whereas item clusters have been described elsewhere as "scaffolded," they are better described as providing structure to the task. For example, some clusters begin with students summarizing data to discover patterns that may have explanatory value. Depending on the grade level and nature of the standard, items may provide complete table shells or labeled graphs to be drawn, or may require the student to choose what to tabulate or graph. Subsequent items may ask the student to note patterns in the tabulated or graphed data and draw on domain content knowledge to posit explanations for the patterns.

These guidelines for clusters do not appear separately in the specifications. Rather, they apply to all clusters.

Structure of the cluster specifications

The item cluster specifications are designed to guide the work of item writers and the review of item clusters by stakeholders.

Each item cluster has the following elements:

- The text of the performance expectations, including the practice, core idea, and cross-cutting concept.
- Content limits, which refine the intent of the performance expectations and provide limits of what may be asked of examinees. For example, they may identify the specific formulae that students are expected to know or not know.
- Vocabulary, which identifies the relevant technical words that students are expected to know, and related words that they are explicitly not expected to know. Of course, the latter category should not be considered exhaustive, since the boundaries of relevance are ambiguous, and the list is limited by the imagination of the writers.
- Sample phenomena, which provide some examples of the sort of phenomena that would support effective

item clusters related to the standard in question. In general, these should be guideposts, and item writers should seek comparable phenomena, rather than drawing on those within the documents. Novelty is valued when applying scientific practices.

- Task demands comprise the heart of the specifications. These statements identify the types of items and activities that item writers should use, and each item written should be clearly linked to one or more of the demands. The verbs in the demands (e.g., select, identify, illustrate, describe) provide guidance on the types of interactions that item writers might employ to elicit the student response. We avoid explicitly identifying interaction types or item formats to accommodate future innovations and to avoid discouraging imaginative work by the item writers.

- For each cluster we present, the printed documentation includes the cluster, the task demands represented by each item, and its linkage to the practice and cross-cutting concept identified in the performance expectation.

Item cluster specifications follow, organized by grade and standard. This collection of item cluster specifications is not exhaustive of all 2014 Oregon Science Standards that may be assessed in the OAKS Science Test.

Performance Expectation MS-ESS1-1

Develop and use a model of the Earth-Sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and the seasons.

Dimensions

Developing and Using Models

- Develop and use a model to describe the phenomena.

ESS1.A: The Universe and Its Stars

- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.

ESS1.B: Earth and the Solar System

- This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth over the year.

Patterns

- Patterns can be used to identify cause and effect relationships.

Clarifications and Content Limits

Content Clarification:

- Examples of models can be physical, graphical, or conceptual.

Assessment Content Limits:

- Students do not need to know Earth's exact tilt; perigee and apogee; sidereal and synodic periods; umbra and penumbra (the term "shadow" should be used); times of moonrise and moonset; precession; exact dates of equinoxes and solstices (but knowledge of the months in which they occur is reasonable to assess).

Science Vocabulary Students Are Expected to Know

- Sun
- Earth
- moon
- shadow
- orbit
- axis
- planet
- satellite
- full moon
- new moon
- half moon

Science Vocabulary Students are Not Expected to Know

- perigee
- apogee
- sidereal period
- synodic period
- synodic month
- umbra
- penumbra
- precession
- equinox
- solstice
- ecliptic
- waxing
- waning
- gibbous
- first quarter moon
- last quarter moon

Phenomena

Some example phenomena for MS-ESS1-1:

- When observed from Earth over the course of a month, the appearance of the moon changes.
- A full moon occurs in every calendar month. However, an eclipse of the moon does not occur in every calendar month.
- A new moon occurs in every calendar month. However, a total eclipse of the sun is a rare event.
- In the northern hemisphere, July is a summer month. In the southern hemisphere, July is a winter month.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Select or identify from a collection of potential model components, including distractors, components needed for a model that can explain lunar phases, eclipses of the sun, eclipses of the moon, or seasons on Earth. Components might include the sun, moon, Earth, solar energy, the moon's orbital trace, Earth's orbital trace, the angle of the moon's orbital trace, the angle of Earth's orbital trace, Earth's axis, or the tilt of Earth's axis.
2. Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing the causes of lunar phases, eclipses of the sun, eclipses of the moon, or seasons on Earth. This does not include labeling a simple diagram of the Earth-sun-moon system.
3. Describe, select, or identify the relationships among components of a model that can explain lunar phases, eclipses of the sun, eclipses of the moon, or seasons on Earth. Components might include the sun, moon, Earth, solar energy, the moon's orbital trace, Earth's orbital trace, the angle of the moon's orbital trace, the angle of Earth's orbital trace, Earth's axis, or the tilt of Earth's axis.
4. Manipulate the components of a model to demonstrate how the relationships among the sun, the moon, Earth, and solar energy change to result in lunar phases, eclipses of the sun, eclipses of the moon, or seasons on Earth. *** (SEP/DCI/CCC)**
5. Make predictions about the effects of changes in the relationships among the sun, the moon, Earth, and solar energy as they relate to lunar phases, eclipses of the sun, eclipses of the moon, or seasons on Earth. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors. *** (SEP/DCI/CCC)**

*denotes those task demands which are deemed appropriate for use in stand-alone item development. 2/3 of these approved TDs should be combined and used when developing a stand-alone item.

Performance Expectation MS-ESS1-4

Construct a scientific explanation based on evidence from rock strata for how the geologic timescale is used to organize Earth's 4.6-billion-year-old history.

Dimensions

Constructing Explanations and Designing Solutions

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

ESS1.C: The History of Planet Earth

- The geological time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.

Scale, Proportion and Quantity

- Time, space, and energy phenomena can be observed at various scales, using models to study systems that are too large or too small.

Clarifications and Content Limits

Content Clarification:

- Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history.
- Example of Earth's major events could range from being geologically recent (e.g., the most recent glacial period or the earliest fossils of Homo sapiens) to geologically very old (e.g., the formation of Earth or the earliest evidence of life).
- Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant instances of volcanic activity.

Assessment Content Limits:

- Assessment does not include recalling the names of specific periods or epochs and events within them. Students do not need to know the types of unconformities (e.g., disconformity, but they should know that unconformities exist).

Science Vocabulary Students Are Expected to Know

- erosion
- weathering
- fossil
- ancient
- prehistoric
- layer
- formation
- strata
- mineral
- sedimentary
- sediment
- metamorphic
- volcanic
- superposition
- cross-cutting
- fault
- fold
- geology
- geological

Science Vocabulary Students are Not Expected to Know

- radioactive dating
- bio-geology
- geobiology
- relative dating
- numerical dating
- absolute dating
- carbon dating
- radiometric dating
- igneous
- stratigraphy
- biostratigraphy
- chronostratigraphy
- sequence
- sequence stratigraphy
- bed, lamina
- paleoenvironment
- paleoecology
- paleomagnetic

Phenomena

Some example phenomena for MS-ESS1-4:

- A very distinct clay layer tops the Hell Creek Formation in Montana. Below this layer, the Hell Creek is rich in dinosaur fossils; above the layer, no dinosaurs are found.
- The landscape of Cape Cod, Massachusetts, is almost entirely small hills of sand and gravel. However, a hole drilled 500 feet into the ground will hit hard metamorphic rock.
- In Box Canyon in Ouray, Colorado, metamorphic rocks that are standing vertical are capped by sedimentary rocks that are lying flat.
- The St. Peter Sandstone is a very white sandstone rock layer exposed in many places in the mid-western United States. The St. Peter is very uniform in appearance but the rock layer sits on top of different kinds of rocks in the North than it does in Missouri.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Organize and/or arrange (e.g., using illustrations and/or labels, including taken from or added to, stratigraphic columns and/or geologic maps), or summarize, data/information so as to highlight trends, patterns, or correlations in paleoenvironmental changes, geological events/processes, and/or the appearance or disappearance in the record of specific organisms. ***(SEP/DCI/CCC)**
2. Generate/construct graphs, tables, or assemblages of illustrations, and/or labels of data/information that document patterns, trends, or correlations in how rock types and included fossils change over geologic time, recording different events and paleo environments. This may include sorting out distractors. ***(SEP/DCI/CCC)**
3. Use relationships identified in the data/information to hypothesize the relative age of specific rock layers, formations, or fossils, in a stratigraphic column or on a geologic map. *(**SEP/DCI/CCC)**
4. Identify patterns or evidence in the data/information that support inferences about what the paleoenvironment was like during time intervals represented in a stratigraphic column or on a geologic map.
5. Describe, identify, and/or select information needed to support an explanation.

*denotes those task demands which are deemed appropriate for use in stand-alone item development. 2/3 of these approved TDs should be combined and used when developing a stand-alone item.

Performance Expectation MS-ESS2-2

Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

Dimensions

Constructing Explanations and Designing Solutions

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future.

ESS2.A: Earth's Materials and Systems

- The planet's systems interact over scales that rage from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

ESS2.C: The Roles of Water in Earth's Surface Processes

- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events.
- Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind.
- Emphasis is on geoscience processes that shape local geographic features, where appropriate.

Content Limits:

- Students are expected to know all of the components/processes of the rock cycle but not specific rock or mineral names.
- Students do not need to know Endogenic or exogenic systems, specific intervals of the Geological Time Scale by name, specific volcano types (shield, effusive, composite, etc.).

Science Vocabulary Students are Expected to Know

- earthquake
- volcanic eruptions
- core
- crust
- mantle
- wind
- temperature
- pressure
- continent
- erosion
- weathering
- million, billion, years
- magma
- lava
- igneous
- sedimentary
- metamorphic
- mineral
- meteor
- crater
- mountain
- plate tectonics
- ocean
- continental drift
- subduction zone
- divergent boundary
- convergent boundary
- hot spot
- fault
- tsunami
- hurricane
- tornado
- fracture
- folding
- Compressing
- sea floor spreading
- layer
- ridge
- rock cycle
- trench
- plateau
- slope
- landslides
- floods
- caves

Science Vocabulary Students are Not Expected to Know

- Endogenic system
- exogenic system
- radiometric dating
- originally horizontality
- superposition
- uniformitarianism
- primordial
- epoch, eon
- period
- liquification
- mohorovicic discontinuity (Moho), seismic waves
- seismograph
- Richter scale
- fumaroles
- mofettes
- solfataras
- caledonian era
- variscan era
- alpine era, massif
- graben
- monolith
- monadnock
- nappe system
- isostasy
- pluton
- batholith
- stratigraphy
- lithification
- evaporite
- hydrothermal
- relief
- topography
- continental shield
- terrain
- anticline
- syncline
- strike-slip fault
- horst, orogenesis
- tephra
- caldera

Phenomena

Some example phenomena for MS-ESS2-2:

- A hillside in Oregon experiences an intense rain storm. At the end of the storm, part of the hillside collapses, covering a road with mud and debris.
- In Northern Arizona, there is a large circular depression.
- In southeastern Pennsylvania, the landscape is dotted with a number of irregular holes that lead to caves.
- When viewed from orbit, the coastline the eastern south line of South America and the Western Coast of Africa look as though they were joined together, similar to a jigsaw puzzle.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features.
2. Express or complete a causal chain explaining how a given process(es) acts to modify Earth's surface in the long term and/or short term. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause and effect chains.
3. Identify evidence supporting the inference of causation that is expressed in a causal chain for a process(es) that acts to modify Earth's surface in the long term and/or short term.
4. Use an explanation to predict the effect of the process on Earth's surface, given a change in conditions (e.g., atmospheric, tectonic, geological, hydrologic).
5. Describe, identify, and/or select information needed to support an explanation for how processes affect Earth's surface over the short and/or long term.

Performance Expectation MS-ESS2-4

Develop a model to describe how the cycling of water through Earth's systems is driven by energy from the sun, gravitational forces, and density.

Dimensions

Developing and Using Models

- Develop a model to describe unobservable mechanisms.

ESS2.C: The Roles of Water in Earth's Surface

- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
- Global movements of water and its changes in form are propelled by sunlight and gravity.

Energy and Matter

- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

Clarifications and Content Limits

Clarification Statements:

- Examples of models can be conceptual or physical.
- Content emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle.
- Practice emphasis is on developing a model and being able to explain reasoning behind choices made relative to the developing or changing of a model. While a few interactions can be about using the model, the focus should not be on using the model or designing an experiment using the model. Any stand-alone items written to this PE should be centered on the development of models..

Content Limits:

- A quantitative understanding of the latent heats of vaporization and fusion is not assessed.
- Students do not need to know:
  - Cloud types
  - Types of aquifers and components of aquifers
  - Concepts of subsurface water flow and transmissivity (e.g., permeability/porosity of the substrate and interactions with fluids; behaviors of subsurface fluids under confinement (both quantitatively and qualitatively).

Science Vocabulary Students are Expected to Know

- precipitation
- transpiration
- evaporation
- condensation
- crystallization
- density
- runoff
- temperature
- air pressure
- particle
- atmosphere

Science Vocabulary Students are Not Expected to Know

- hyporheic zone
- aquifer
- aquitard
- aquiclude
- subsurface flow
- sublimation
- vadose zone
- unsaturated zone
- water table
- phreatic surface
- capillary fringe
- saturated zone
- phreatic zone
- drainage basin
- watershed
- porosity
- permeability
- transmissivity
- recharge
- recharge area
- discharge
- discharge area
- potentiometric surface
- hydraulic head
- lithosphere
- biosphere
- hydrosphere
- cryosphere

Phenomena

Some example phenomena for MS-ESS2-4:

- When driving over a bridge on a cool morning, you see fog over the river but not over the land.
- Morning fog and mist soon disappears after the sun rises on a clear day.
- The Blue Mountains have snow that melts (eventually) into the Columbia River to the John Day Dam.
- In the Iowa cornfields in the summer, a dense dome of humidity forms over the cornfields.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Select or identify from a collection of potential model components including distractors, the components needed to model the model of evaporation, condensation, transpiration, precipitation or other behaviors of water molecules during the water cycle.
2. Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing the phenomenon. This does not include labeling an existing diagram. ***(SEP/DCI/CCC)**
3. Manipulate the components of a model to demonstrate the effects those adjustments would have on the behavior of water in the water molecules in the water cycle. ***(SEP/DCI/CCC)**
4. Make predictions about the effects of changes to the parts of the model. Predictions can be based on manipulating model components, completing illustrations, or selecting from a list with distractors.
5. Identify missing components, relationships, or other limitations of the model.
6. Describe, select, or identify the relationships among components of a model that describe or explains the phenomenon.
7. Identify, describe or explain reasons for choosing components of a model of the water cycle.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

Performance Expectation MS ESS2-5

Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

Dimensions

Planning and Carrying Out Investigations

- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

ESS2.C: The Roles of Water in Earth's Surface Processes

- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

ESS2.D: Weather and Climate

- Because these patterns are so complex, weather can only be predicted probabillistically.

Cause and Effect

- Cause and Effect relationships may be used to predict phenomena in natural or designed system.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide.
- Emphasis is on how weather can be predicted within probabilistic ranges.
- Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as condensation).

Content Limits:

- Weather incidents internal to air masses are excluded because the focus is on the interfaces between large scale air masses.
- Students do not need to know: Names of the various types of clouds, weather symbols used on weather maps, weather symbols used on reports from weather stations. A legend will be included on weather maps.

Science Vocabulary Students Are Expected to Know

- density
- temperature
- pressure
- humidity
- precipitation
- wind speed
- wind direction
- air mass
- cold/warm front
- condensation
- evaporation
- latitude
- altitude
- flow
- thermometer
- barometer
- anemometer
- relative humidity

The listing of devices is supported by evidence statement 3.a "Students describe the tools and methods used in the investigation." This also implies inclusion of measurement units- degrees Fahrenheit, degrees Celsius, atmospheric pressure units (inches/millimeters of mercury, hectopascals)

Science Vocabulary Students Are Not Expected to Know

- cumulus
- cumulonimbus
- cirrus
- stratus
- alto- and nimbo- as modifiers
- cyclone
- anticyclone
- isobar
- isotherm
- pressure gradient
- Coriolis force*
- hygrometer
- psychrometer (humidity meters)
- jet stream
- dew point
- stationary front
- occluded front

*Coriolis force IS covered in PE MS-ESS2-6

Phenomena

Some example phenomena for MS-ESS2-5:

- One fall day starts out warm and fairly still. The wind picks up and the temperature drops and it begins to rai.
- The flag outside a school has been resting against the flagpole, unmoving all morning. In the early afternoon, it starts flapping in the wind. At sunset, rain begins.
- Fall days were chilly, then the temperature warmed up for a few days.
- A tornado formed in the Pacific Ocean near Oregon.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Evaluate the sufficiency and limitations of data collected to explain the phenomenon.
2. Identify the outcome data that should be collected in an investigation of the interactions of air masses and the resulting changes in weather conditions.
3. Make and/or record observations about the interactions of air masses and/or the relationships between those interactions and patterns of weather in a particular location.
4. Describe, illustrate, or select tools, locations, and/or methods to use in investigations of phenomena related to interactions of air masses. This should show how or where measurements will be taken.
5. Identify, select, or describe the relevance of particular data or sources relevant to the process of weather forecasting.
6. Predict the effects of given changes in the air masses' interactions on subsequent weather.
7. Identify or specify inferences supported by data collected.

Performance Expectation MS ESS2-6

Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Dimensions

Developing and Using Models

- Develop and use a model to describe phenomena.

ESS2.C: The Roles of Water in Earth's Surface Processes

- Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.

ESS2.D: Weather and Climate

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

Systems and System Models

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution.
- Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis Effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis Effect and the outlines of continents.
- Examples of models can be diagrams, maps and globes, or digital representations.

Content Limits:

- Students do not need to know: names of specific winds, different cloud types (cumulus, cirrus etc.), names of specific ocean currents, or perform any quantitative analyses based on the Coriolis Effect, mathematical calculations beyond trends, or measurements of central tendency.

Science Vocabulary Students Are Expected to Know

- weather
- climate
- temperature
- atmospheric pressure
- density
- current
- latitude
- altitude
- Coriolis effect
- convection
- condensation
- precipitation
- cloud, water cycle
- air mass circulation
- vegetation
- latitude
- longitude
- rain shadow

Science Vocabulary Students Are Not Expected to Know

- trade winds
- easterlies
- westerlies
- cumulus
- cirrus or other cloud names
- gulf stream
- labrador
- ocean current names
- UV rays

Phenomena

Some example phenomena for MS-ESS2-6:

- In December 2010, Gary, Indiana, on the southeast shores of Lake Michigan, had approximately 30 inches of snow over a three-day period, whereas Chicago, Illinois, 30 miles away, received barely any snow.
- Onshore and offshore breezes—in the morning, the breeze comes in from the ocean. At night, the breeze is blowing in the opposite direction.
- Wind storms in the Sahara become hurricanes that affect the east coast of North America and the Caribbean, but not the coast of South America.
- The Westerlies vs. The Easterlies and the trade winds—why are these wind patterns banded as you move north from the equator?

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Assemble or complete an illustration or flow chart that is capable of representing the effect of unequal heating of Earth's systems on atmospheric and oceanic circulation. Key components of the model might include: oceans, land forms, wind current, ocean current, energy flows, upwelling, downwelling, water temperature, and salinity.
2. Manipulate the components of a model to demonstrate the changes, properties, processes, and/or events that act to result in a phenomenon.
3. Make predictions about the effects of changes in temperature on a phenomenon. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors. Make predictions about the effects of changes in water temperature or density, distance from the lake, location, etc.
4. Identify missing components, relationships, or other limitations of a model.
5. Describe, select, or identify the relationships among components of a model that explain the effect of unequal heating of Earth's systems on atmospheric and oceanic circulation.

Performance Expectation MS-ESS3-2

Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Dimensions

Analyzing and Interpreting Data

- Analyze and interpret data to determine similarities and differences in findings.

ESS3.B: Natural Hazards

- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.

Patterns

- Graphs, charts, and images can be used to identify patterns in data.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable.
- Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods).
- Examples of data can include the locations, magnitudes, and frequencies of the natural hazards.
- Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).

Content Limits:

- Analysis may include recognizing patterns in data, identifying periodicity, straightforward mathematical comparisons (more, less, faster, slower), examining trends, looking for differences in tabular data, qualitative spatial analysis (e.g., looking at fault lines), recognizing trends and patterns. May include drawing lines of best fit and extrapolating from those lines.
- Analysis should not include regression analysis or calculating correlations.

Science Vocabulary Students are Expected to Know

- accuracy
- air mass
- air mass circulation
- altitude
- atmospheric
- atmospheric circulation
- average
- biosphere
- carbon dioxide
- climate change
- climatic pattern
- condensation
- constrain
- convection cycle
- Coriolis effect
- cyclical
- density
- determinant
- distribution
- latitude
- latitudinal
- longitude
- longitudinal
- mass
- oceanic
- ocean circulation
- orbit
- orientation
- pressure
- probabilistic
- redistribute
- salinity
- solar
- store
- tectonic
- tectonic cycle
- tilt
- time scale
- transfer
- unequal heating of air
- unequal heating of land masses
- unequal heating of oceans
- weather map
- catastrophic
- debris
- development
- economic
- frequency
- geologic
- impact
- interdependent
- magnitude
- mass wasting
- natural process
- reservoir
- satellite

Science Vocabulary Students are Not Expected to Know

- concentration
- electromagnetic radiation
- radiation
- sea level

Phenomena

For this performance expectation, the phenomena are sets of data. Those are the observed facts that the kids will look at to discover patterns. Below, we enumerate some of the patterns that might comprise the data sets (phenomena) to be analyzed.

Some example phenomena for MS-ESS3-2:

- A sequence of maps illustrates temperature patterns and occurrence of tornados over the course of the year (to identify variations of tornado risk across regions and also to identify more proximate predictors of tornados).
- A sequence of maps illustrates temperature and humidity patterns and occurrence of hurricanes over the course of the year (to identify variations of hurricane risk across regions and also to identify more proximate predictors of hurricanes).
- Temperature and humidity patterns in the Pacific Ocean can be correlated to the snow pack on Mt. Hood.
- A map of average snowfall in the Great Lakes region shows more snow has fallen in locations nearer to the lakes. Data include surface temperatures, water temperature, wind patterns and snowfall.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Organize/Arrange data to highlight patterns, trends, or correlations. ***(SEP/DCI/CCC)**
2. Tabulate/Graph data to highlight patterns, trends, or correlations. ***(SEP/DCI/CCC)**
3. Use relationships identified in the data to predict events.
4. Illustrate or describe patterns over time that can be used to predict events. ***(SEP/DCI/CCC)**
5. Identify human and societal responses designed to mitigate catastrophic events.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

Performance Expectation MS-ESS3-3

Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Dimensions

Constructing Explanations and Designing Solutions

- Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progress to include constructing explanations and designing solutions supported with scientific ideas, principles, and theories.
- Apply scientific principles to design an object, tool, process or system.

ESS3.C: Human Impacts on Earth Systems

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing extinction of other species. But change to Earth's environments can have different impacts (negative and positive) for different living things.

Cause and Effect

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.

Clarifications and Content Limits

Clarification Statements:

- Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact.
- Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the constructions of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as air, water, or land).

Content Limits:

- Students will not describe the relationship between natural resources and sustainability.

Science Vocabulary Students are Expected to Know

- diversity
- societal
- wetland
- agriculture
- biosphere
- development
- fertile
- groundwater
- industry
- material world
- mineral
- river delta
- aquifer
- Earth system
- economic
- human activity
- human impact
- land usage
- levee
- water usage
- consumption

Science Vocabulary Students are Not Expected to Know

- anthropogenic changes
- consumption
- per-capita
- urban development
- biomass
- degradation
- destabilize
- geoengineering
- ozone
- pollutant
- sea level
- stabilize
- waste management
- harvesting of resources
- cost-benfit

Phenomena

Engineering PE’s are built around meaningful design problems rather than phenomena.
Some example design problems for MS-ESS3-3:

- Nurdles are small plastic pellets, smaller than a pea. Billions of them are used in creating plastic products. Many fall out of the truck or ship container that they are transported in and end up in oceans where they are mistaken as food by marine animals.
- Glen Canyon Dam is located on the Arizona and behind it sits Lake Powell the second largest reservoir in the United States. Glen Canyon Dam holds back sediment that would naturally replenish downstream ecosystems. The sediment that is trapped behind the dam is filling Lake Powell at a rate of roughly 100 million tons of sediment a year, decreasing the dam’s ability to store water
- Farmers in Iowa plow their fields in the spring in order to break up the thick soil and disrupt weeds from growing. The practice of plowing however, causes farmers to lose valuable top soil due to wind erosion.
- In the central North Pacific Ocean there is what is described as a great garbage patch. This large area has high concentrations of plastics, fishing nets, and other debris. This debris is sometimes mistaken as food by marine animals.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Identify or assemble from a collection, including distractors, the relevant aspects of human impact on the environment that given design solutions, if implemented, will resolve/improve.
2. Using the given information about human impact on the environment, select or identify the criteria against which the device or solution should be judged.
3. Using given information about human impact on the environment, select or identify constraints that the device or solution must meet.
4. Using given data, propose/illustrate/assemble a potential device (prototype) or solution to monitor and/or minimize human impact on the environment.
5. Using a simulator, test a proposed prototype and evaluate the outcomes, potentially including proposing and testing modifications to the prototype.

Performance Expectation MS-ESS3-4

Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Dimensions

Engaging in Argument from Evidence

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

ESS3.C: Human Impacts on Earth Systems

- Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth, unless the activities and technologies involved are engineered otherwise.

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Clarifications and Content Limits

Clarification Statements:

- Emphasize that these resources are limited and may be non-renewable
- Examples of evidence include rates of consumption of food and natural resources such as fresh water, minerals, and energy sources.
- Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.

Content Limits:

- Assessment is limited to one form of consumption and its associated impacts.
- Students do not need to know: mechanisms or details about interior geological processes, quantities and types of pollution released, changes to biomass and species diversity, or changes in land surface use.

Science Vocabulary Students are Expected to Know

- conservation
- recycling
- perishable
- synthetic
- manufactured
- rivers
- lakes
- groundwater
- fertile
- delta
- fossil fuels
- pollution
- composition
- glacier
- mass
- volume
- concentration

Science Vocabulary Students are Not Expected to Know

- tar sands
- oil shales
- agricultural efficiency
- urban planning
- aesthetics
- biomass
- glacial ice volumes
- hydrosphere
- cryosphere
- geosphere
- acidification
- empirical evidence
- polar caps

Phenomena

Some example phenomena for MS-ESS3-4:

- Lake Urmia in Iran was once the nation's largest lake. Today, the lake is 5% as large as it used to be.
- In 1990, much of the tropical rain forests on the Hainan Island were clear-cut to obtain wood, and to create space for plantations. Today, the forests are still smaller and less developed than they were before 1990.
- A coal power plant in Martins Lake, Texas, releases huge clouds of gas into the air every day.
- The open-pit copper mine Ok Tedi Mine in Papua, New Guinea, releases its drainage nearby. Downstream, the rivers turned orange and the fish died.
- Mountains Pike County, Kentucky, has had their mountaintops removed, and are flat on top.
- Over the past 30 years, the Aral Sea in the former Soviet Union has shrunk to less than half its original size.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information.
2. Predict outcomes when properties or amounts of consumption are changed, given the inferred cause and effect relationships.
3. Describe, identify, and/or select information needed to support an explanation of how increases in human population and per-capita consumption of natural resources impact Earth's systems.
4. Identify patterns or evidence in the data that support conclusions about the relationship between per capita consumption and limited natural resources.***(SEP/DCI/CCC)**
5. Using evidence, explain the relationship between per capita consumption and limited natural resources.***(SEP/DCI/CCC)**
6. Manipulate the components of a model to demonstrate the changes, properties, processes, and/or events that act to result in the phenomenon. ***(SEP/DCI/CCC)**

*denotes those task demands which are deemed appropriate for use in stand-alone item development

Performance Expectation MS-LS1-1

Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.

Dimensions

Planning and Carrying Out Investigations

- Conduct an investigation to produce data to serve as the basis for evidence that meets the goals of an investigation.

LS1.A: Structure and Function

- All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).

Scale, Proportion, and Quantity

- Phenomena that can be observed at one scale may not be observable at another scale.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many varying cells.

Content Limits:

Students do not need to know:

- The structures or functions of specific organelles or different proteins
- Systems of specialized cells
- The mechanisms by which cells are alive
- Specifics of DNA and proteins or of cell growth and division
- Endosymbiotic theory
- Histological procedures

Science Vocabulary Students Are Expected to Know

- multicellular
- unicellular
- cells
- tissues
- organ
- system
- organism hierarchy
- bacteria
- colonies
- yeast
- prokaryote
- eukaryote
- magnify
- microscope
- DNA
- nucleus
- cell wall
- cell membrane
- algae, chloroplast(s)
- chromosomes
- cork

Science Vocabulary Students Are Not Expected to Know

- differentiation
- mitosis
- meiosis
- genetics
- cellular respiration
- energy transfer
- RNA
- protozoa
- amoeba
- histology
- protista
- archaea
- nucleoid
- plasmid
- diatoms
- cyanobacteria

Phenomena

Some example phenomena for MS-LS1-1:

- Plant leaves and roots have tiny box-like structures that can be seen under a microscope.
- Small creatures can be seen swimming in samples of pond water viewed through a microscope.
- Different parts of a frog's body (muscles, skin, tongue, etc.) are observed under a microscope, and are seen to be composed of cells.
- One-celled organisms (bacteria, protists) perform the eight necessary functions of life, but nothing smaller has been seen to do this.
- Swabs from the human cheek are observed under a microscope. Small cells can be seen.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Identify from a list, including distractors, the materials/tools needed for an investigation to find the smallest unit of life (cell).
2. Identify the outcome data that should be collected in an investigation of the smallest unit of living things.
3. Evaluate the sufficiency and limitations of data collected to explain that the smallest unit of living things is the cell.
4. Make and/or record observations about whether the sample contains cells or not. ***(SEP/DCI/CCC)**
5. Interpret and/or communicate data from the investigation to determine if a specimen is alive or not.
6. Construct a statement to describe the overall trend suggested by the observed data.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

Performance Expectation MS-LS1-2

Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.

Dimensions

Developing and Using Models

- Develop and use a model to describe phenomena.

LS1.A: Structure and Function

- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.

Structure and Function

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts; therefore, complex natural structures/systems can be analyzed to determine how they function.

Clarifications and Content Limits

Clarification Statements:

- Emphasize the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.

Content Limits:

- Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane.
- Assessment of the function of the other organelles is limited to their relationship to the whole cell.
- Assessment does not include the biochemical function of cells or cell parts.
- Students do not need to know: protein synthesis, cell division (mitosis), reproduction (meiosis)
- No relation of cell to organism function.

Science Vocabulary Students Are Expected to Know

- eukaryote
- prokaryote
- nucleus
- chloroplast
- mitochondrion
- cell membrane
- cell wall
- diffusion
- osmosis
- photosynthesis
- cellular respiration
- sugar
- DNA
- RNA
- energy
- bacteria
- cytoplasm
- organelle

Science Vocabulary Students Are Not Expected to Know

- golgi
- ribosome
- endoplasmic reticulum
- enzyme
- replication
- mitosis
- meiosis
- glucose
- chromosome
- protein channels
- lysosome
- vacuole
- peroxisome
- thylakoid
- stroma
- granum
- nuclear envelope
- nucleolus
- flagellum
- cytoskeleton
- microvilli
- chromatin
- plasmodesmata
- micorfilaments
- microtubules
- fimbriae
- nucleoid
- capsule
- flagella
- nucleoid
- plasma membrane
- cytosol
- phagocytosis
- endocytosis
- cristae

Phenomena

Some example phenomena for MS-LS1-2:

- Skin cells act as a barrier between your insides and the outside.
- Under a microscope, a muscle cell looks different than a skin cell.
- Under a microscope, a root cell looks different than a leaf cell.
- A human sperm cell is smaller than a human egg cell.
- An E. coli bacterium is approximately the same size as the mitochondria of a mammalian lung cell.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Assemble or complete, from a collection of potential model components, an illustration that is capable of representing a eukaryotic (plant and/or animal) or prokaryotic cell in terms of the function of the cell.
2. Select or identify from a collection of potential model components, including distractors, the components needed to model the phenomenon. Components might mirror the cell wall, cell membrane, nucleus, chloroplast, and/or mitochondrion. This does not include labeling an existing diagram.
3. Manipulate the components of a model to demonstrate the changes, properties, and/or events that act to result in the phenomenon. *(SEP/DCI/CCC)
4. Given models or diagrams of cells, identify the functions of each part of the cell.
5. Identify missing components, relationships, or other limitations of the model.
6. Describe, select, or identify the relationships among components of a model that together function as a cell.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

Performance Expectation MS-LS1-5

Construct a scientific explanation based on evidence for how environment and genetic factors influence the growth of organisms.

Dimensions

Constructing Explanations and Designing Solutions

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

LS1.B: Growth and Development of Organisms

- Genetic factors as well as local conditions affect the growth of the adult plant.

Structure and Function

- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be describe using probability.

Clarifications and Content Limits

Clarification Statements:

- Examples of local environmental conditions could include availability of food, light, space, and water.
- Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms.
- Examples of evidence could include a drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.

Content Limits:

- Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.
- Assessment does not include Punnett squares.
- Students do not need to know: epigenetics or variations of gene expression.

Science Vocabulary Students Are Expected to Know

- gene
- genetics
- genome
- genotype
- environment
- growth
- development
- DNA

Science Vocabulary Students Are Not Expected to Know

- epigenetics
- RNA
- gene expression
- photoperiod

Phenomena

Phenomena for this PE should include two groups of a particular organism with one environmental change.
Some example phenomena for MS-LS1-5:

- An orchard contains both full-sized and dwarf apple trees. Individuals of both types of tree grow shorter and produce fewer apples when planted on a dry hillside, and grow taller and produce more apples when planted on the shore of a pond. (i.e., the full apple trees on the hillside are the same size with similar apple production as the dwarf apple trees by the pond).
- Only about 90% of identical twins each have the same height.
- A group of poinsettias and daisies are grown in the same greenhouse. The poinsettias bloom when exposed to ten consecutive hours of light, but the daisies bloom when exposed to 14 consecutive hours of light.
- Burrs are dispersed to different environments by traveling on the fur of mammals. Some seeds from a burr plant drop off into a sunny field, while others drop off into a shady patch of woods. The burr plants that grew in the sun are taller and produced more burrs than those that grew in the shade.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Articulate, describe, illustrate, or select genetic and/or environmental influences on phenotypic differences between organisms. This may entail sorting relevant from irrelevant information.
2. Explain the process by which genetic factors and/or local conditions cause the observed phenomenon, supporting the explanation with valid and reliable evidence.
3. Identify evidence that supports the inference that genetic and environmental factors influence growth and development of organisms. Environmental factors may include food, light, space, and water.
4. Describe, identify, and/or select information from one or more sources to support an explanation for phenotypic differences in organisms related to genetic and environmental factors.

Performance Expectation MS-LS1-8

Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Dimensions

Obtaining, Evaluating, and Communicating Information

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how theya re supported or not supported by evidence.

LS1.D: Information Processing

- Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural systems.

Clarifications and Content Limits

Content Limits:

- Assessment does not include mechanisms for the transmission of information from sensory receptors to the brain.
- Students do not need to know: Sensory transduction, ion channels, action potentials, sensory and motor cortices in the brain.

Science Vocabulary Students Are Expected to Know

- senses
- chemical
- mechanical
- memory
- perception
- process
- storage
- transfer
- transmit
- accuracy
- cell
- immediate
- nerve
- receptor
- sensory
- behavioral response to stimuli
- electromagnetic
- stimulus
- short-term memory
- long-term memory
- salt
- sour
- sweet
- bitter
- brain
- nervous system
- taste
- smell
- touch
- hear
- sight

Science Vocabulary Students Are Not Expected to Know

- neuron
- neurotransmitter
- endocrine signaling
- synapse
- axon
- olfactory
- rods
- cones
- trichromatic vision
- retina
- hair cells
- cochlea
- fight-or-flight response
- sensitization
- depolarization
- taste papillae
- umami

Phenomena

Some example phenomena for MS-LS1-8:

- A woman closes her eyes and touches the tip of her nose with her index finger
- A student is studying in a library. The fire alarm goes off and he involuntarily jumps out of his chair.
- A woman walking past a bakery smells cinnamon and is instantly reminded of her grandmother's house.
- A driver sees a stoplight change from green to red and quickly moves his foot from the accelerator pedal to the break.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Analyze and interpret scientific evidence from multiple scientific/technical sources including text, diagrams, charts, symbols and mathematical representations to describe how external stimuli are sensed by the brain.
2. Assemble or complete an illustration or flow chart representing physiological or behavioral responses to external stimuli.
3. Based on the information provided, identify or describe supporting evidence for an argument regarding the relationship between an external stimulus, sensory receptors and/or a particular behavior.
4. Make predictions about the effects on sensory receptors, immediate behavior, or memory storage as a result of changes to an external stimulus. Predictions can be quantitative or qualitative and can be made by completing illustrations, or selecting from lists with distractors.
5. Evaluate the validity, credibility, accuracy, relevancy and/or possible bias of scientific/technical sources.
6. Synthesize an explanation regarding sensory stimuli that incorporates scientific evidence from multiple sources.
7. Identify, summarize, or organize given data or other information to support or refute a claim relating the characteristics of an external stimulus to a sensory pathway.

Performance Expectation MS-LS2-1

Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Dimensions

Analyzing and Interpreting Data

- Analyze and interpret data to provide evidence of phenomena.

LS2.A: Interdependent Relationships in Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions, both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on cause and effect relationships between resources and growth of individual organisms, and the numbers of organisms in ecosystems during periods of abundant and scarce resources.
- Examples could include water, food, and living space.

Content Limits:

- Assessment does not include mathematical and/or computational representations of factors related to carrying capacity of ecosystems of different sizes (including deriving mathematical equations to make comparisons).

Science Vocabulary Students Are Expected to Know

- resource
- competition
- ecosystem
- nutrient
- food chain/web
- producer
- consumer

Science Vocabulary Students Are Not Expected to Know

- biotic component
- abiotic component
- exponential (AKA "logistic" growth
- ecological niche
- resource partitioning
- fundamental niche
- realized niche
- carrying capacity
- intraspecific competition
- interspecific competition

Phenomena

The phenomenon for these PEs are the given data. Samples of phenomena should describe the data set(s) to be given in terms of patterns or relationships to be found in the data, and the columns and rows of a hypothetical table presenting the data, even if the presentation is not tabular. The description of the phenomenon should describe the presentation format of the data (e.g., maps, tables, graphs, etc.).

Some example phenomena for MS-LS2-1:

- On the north Atlantic coastline, two species of barnacles live at different depths.
- Cheetahs and leopards in the savannah use the same watering holes.
- After a drought period, the population of grasshoppers is halved.
- A garden is cleared of aphids. After a few days, the ladybirds in the surrounding trees are gone.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Organize and/or arrange (e.g., using illustrations and/or labels), or summarize data to highlight trends, patterns, or correlations between resource availability and the growth of a population or populations of organisms.
2. Generate or construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends, or correlations between resource availability and the growth of a population or populations of organisms. This may include sorting out distractors.***(SEP/DCI/CCC)**
3. Use relationships identified in resource/population data to predict the change in a population or populations or the change in resources that resulted in a change in populations. ****(SEP/DCI/CCC)**
4. Identify patterns or evidence in the data that supports inferences and explanations about how resource availability affects a population of organisms. ***(SEP/DCI/CCC)**
5. Construct or identify testable questions that can be asked to collect data about how resource availability may affect the growth of a population or populations of organisms.
6. Identify, describe, or select from a collection characteristics to be manipulated or held constant while gathering information to answer a well-articulated question. ***(SEP/DCI/CCC)**
7. Select or describe inferences relevant to the question posed and supported by the data, especially inferences about causes and effects.
8. Select, identify, or describe predicted outcomes when specific changes in resource availability occur, using inferences about cause and effect relationships involving those resources. ****(SEP/DCI/CCC)**

*denotes those task demands which are deemed appropriate for use in stand-alone item development
**TD3 and TD8 must be used together.

Performance Expectation MS-LS2-3

Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Dimensions

Developing and Using Models

- Develop a model to describe phenomena.

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

- Food webs are models that demonstrate how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

Energy and Matter

- The transfer of energy can be tracked as energy flows through a natural system.

Clarifications and Content Limits

Clarification Statements:

- Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems.
- Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.

Content Limits:

- Assessment does not include the use of chemical reactions to describe the processes.
- Assessment does not include identification of trophic levels, understanding of the relative energies of the trophic levels, nor the knowledge of the 10% energy transfer between trophic levels.
- Assessment does not include the concept of biomass.
- Assessment does not include the process of bioaccumulation.
- Students do not need to identify biomes or to know information about specific biomes.

Science Vocabulary Students Are Expected to Know

- food web
- food chain
- producer
- consumer
- decomposer
- herbivore
- omnivore
- carnivore
- algae
- fungi
- microbe
- microorganism
- organic matter/waste
- nutrients
- photosynthesis
- atom
- molecule
- sugar
- carbon
- carbon Dioxide
- nitrogen
- oxygen
- Law of conservation of matter
- Law of conservation of energy
- predator
- prey
- atmosphere
- aquatic
- interdependent

Science Vocabulary Students Are Not Expected to Know

- biotic
- abiotic
- trophic level
- energy pyramid
- nitrogen fixation
- exothermic/endothermic
- detritivores
- biomass
- bioaccumulation/biomagnification
- autotroph/heterotroph
- biosphere
- hydrosphere
- geosphere
- aerobic
- anaerobic
- chemical reaction
- reactant
- product
- phosphorous
- phytoplankton

Phenomena

Some example phenomena for MS-LS2-3

- In the Alaskan tundra, more grass and wildflowers grow on top of underground fox dens than elsewhere.
- In July, a colony of lava crickets is found to inhabit lava flows from a May eruption, but the first plant does not appear in the area until November.
- Fox-inhabited islands in the Aleutian Islands have less vegetation than islands not inhabited by foxes.
- Giant clams and tube worms are found in the darkest parts of the oceans in the hot water near hydrothermal vents.

Task Demands Supported by This Performance Expectation and associated Evidence Statements

1. Identify, assemble, or complete from a collection of potential model components, including distractors, components of a food-web model that describe transfers of matter and/or energy among producers, consumers, decomposers, or some subsets of those, potentially including transfers between living and nonliving organisms.
2. Describe, select, or identify the relationships among components of a food-web model that describes how parts of the food web (producers, consumers, and decomposers) interact to continually cycle matter and to transfer energy among living and nonliving parts of an ecosystem.
3. Manipulate the components of a food-web model to demonstrate how the interactions among producers, consumers, and/or decomposers result in changes to the cycling of matter and/or transfer of energy among living and nonliving parts of an ecosystem.
4. Select, describe, or illustrate predictions about the effects of changes in the organisms or nonliving components of the environment on the cycling of matter, transfer of energy, and/or other organisms in the environment. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.
5. Select or identify missing components or relationships of a food web model that describes the transfers of matter and/or energy among living and nonliving parts of an ecosystem.

Performance Expectation MS-LS2-4
Construct an argument supported by evidence that the stability of populations is affected by changes to an ecosystem.

Dimensions
Engaging in Argument from Evidence
- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- Ecosystems are dynamic in nature: their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

Stability and Change
- Small changes in one part of a system might cause large changes in another part.

Clarifications and Content Limits
Clarification Statements:
- Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem.
- Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.
- Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands, and deserts.

Content Limits:
- Assessment does not include the use of chemical reactions to describe the processes.

Science Vocabulary Students Are Expected to Know
- predator
- mutually beneficial interactions
- competition
- food web
- consumers
- producers
- decomposers
- biodiversity

Science Vocabulary Students Are Not Expected to Know
- anthropogenic changes
- carrying capacities

Phenomena
Some example phenomena for MS-LS2-4:
- After a beaver builds a dam, the amount and diversity of fish life in a stream increases.
- After wolves were reintroduced to Yellowstone, there were more willows.
- The number of willows has increased in Yellowstone. (Give two competing hypotheses: wolf introduction; beaver population increase).
- As the Aral Sea declined in size since the 1960s, salinity has increased and the Aral trout is no longer present in the lake.
- The area of the Gulf of Mexico around the Mississippi Delta has large algal blooms.

Task Demands Supported by This Performance Expectation and associated Evidence Statements

1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or information supporting/refuting one or more competing hypotheses.
2. Predict outcomes when changes to an ecosystem occur, given the inferred cause and effect relationships. ***(SEP/DCI/CCC)**
3. Identify, select, and/or describe information or evidence needed to support one or more potentially competing explanations.
4. Identify patterns of information/evidence in the data that support correlative/causative inferences about the relationships among the pertinent parts of an ecosystem. ***(SEP/DCI/CCC)**
5. Organize and/or arrange (e.g., using illustrations and/or labels) or summarize population data to highlight trends, patterns, or correlations.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

Performance Expectation MS-LS2-5

Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Dimensions

Engaging in Argument from Evidence

- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystems' biodiversity is often used as a measure of its health.

LS4.D: Biodiversity and Humans

- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on-for example, fresh air and water (secondary).

ETS1.B: Ecosystem Dynamics, Functioning, and Resilience

- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem (secondary).

Stability and Change

- Small changes in one part of a system may cause a large change in another.

Clarifications and Content Limits

Clarification Statements:

- Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion.
- Examples of design solution constraints could include scientific, economic, and social considerations.

Content Limits:

- Students do not need to know: specific policies or specific details of organisms.

Science Vocabulary Students Are Expected to Know

- habitats
- ecosystem
- niche
- native species
- non-native or invasive species
- biodiversity
- resources

Science Vocabulary Students Are Not Expected to Know

- specific species names
- specific resource or habitat requirements for any species

Phenomena

Engineering PE's are built around meaningful design problems rather than phenomena. In this case, the design problems involve preserving ecosystems and protecting biodiversity. For this PE, the design problem and competing solutions replace phenomena.

Some example design problems for MS-LS2-5:

- Giant African Land Snails were brought to Florida by a boy who smuggled three snails into Florida. His grandmother released these into a garden and the snail population exploded. The snails eat over 500 plant species, tree bark, paint, and even stucco. Florida has implemented four solutions:
  - Trained dogs that sniff out snails for capture.
  - Chemicals applied to plants that the snails feed upon.
  - Predatory species to eat the snails.
- The brown tree snake was accidentally brought to the island of Guam by ships during World War II, fed on native birds until the Guam rail, a native bird, nearly went extinct in 1984. Guam has implemented two solutions:
  - Feed rats acetaminophen and drop them into wooded areas.
  - Bring in predatory species to eat the snakes.
- Cheatgrass, a type of weed that was brought to the United States in the late 1800s, has spread all over Utah from the desert valleys to the mountains, growing faster than most native plants. Utah has implemented two solutions:
  - Use genetically modified seeds for certain native seeds that are heartier than the Cheatgrass to push out the Cheatgrass seeds.
  - Controlled application of herbicides.
- Asian carp is an aggressive fish species introduced in 1960 to control weed populations in waterways in southern fish farm ponds. The population was sterilized but a few fertile fish escaped into the Mississippi River and migrated north towards the Great Lakes. Asian carp are an invasive species that compete with native fish in the Great Lakes and threaten the ecosystem balance. Regions around the Great Lakes are implementing strategies:
  - Launch a campaign to encourage and incentivize fishing of Asian carp for human consumption
  - Use a system of electric barriers to prevent Asian carp form entering Lake Michigan form the Mississippi River.
  - Use nets to block to popular spawning sites during Asian carp reproduction season
  - Introduce a botanic pesticide used for fish eradications in water areas known to have large Asian carp populations.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Identify or assemble from a collection, including distractors, the relevant aspects of the problem that, given design solutions if implemented, will resolve/improve maintaining biodiversity and ecosystem services.
2. Using given information for maintaining biodiversity and ecosystem services, select or identify constraints that the device or solution must meet.
3. Using the given information for maintaining biodiversity and ecosystem services, select or identify the criteria against which the device or solution should be judged.
4. Compare, rank, or otherwise evaluate the different design solutions for maintaining biodiversity and ecosystem services against the identified criteria.
5. Select or propose a recommended course of action supported by the design solution's ability to meet identified criteria.

Performance Expectation MS-LS3-2

Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

Dimensions

Developing and Using Models

- Develop and use a model to describe phenomena.

LS1.B: Growth and Development of Organisms

- Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring (secondary).

LS3.A: Inheritance of Traits

- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.

LS3.B: Variation of Traits

- In sexually reproducing organisms, each parent contributes (at random) half of the genes acquired by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural systems.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on using models such as Punnett Squares, diagrams and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.

Content Limits:

- Assessment does not include phases of mitosis or meiosis.
- Students do not need to know process of recombination.

Science Vocabulary Students Are Expected to Know

- breed
- transfer
- development
- germination
- plant structure
- plumage
- reproductive system
- fertilizer
- gene
- genetic
- variation
- allele
- dominant trait
- recessive trait
- hereditary information
- Punnett square
- transmission
- chromosome
- sexual reproduction
- asexual reproduction
- protein

Science Vocabulary Students Are Not Expected to Know

- DNA
- DNA replication
- sex-linked trait
- recombination
- gene expression
- segment
- sex cell
- sex chromosome
- cell division
- mutation
- meiosis
- amino acid
- amino acid sequence
- haploid
- diploid

Phenomena

Some example phenomena for MS-LS3-2:

- Jellyfish will produce both clones and genetically diverse offspring during different stages of their life cycle.
- Strawberry plants grow another stem from a core stem that extends horizontally on the ground. This new stem will become a separate strawberry plant.
- A flatworm is cut in half. Rather than dying, both halves regenerate their lost portions to form two new, distinct, and fully functioning worms.
- A plant (Bryophyllum diagremontianum) native to Madagascar has what appears to be miniature clusters of leaves lining the edges of a much larger leaf.

Task Demands Supported by This Performance Expectation and Associated Evidence Statements

1. Select or identify from a collection of potential model components, including distractors, the components needed to model the phenomenon. Components might include alleles, genotypes, and phenotypes.
2. Assemble or complete, from a collection of potential model components, an illustration or flow chart that is capable of representing different types of reproduction. This does not include labeling an existing diagram.
3. Manipulate the components of a model to demonstrate the changes, properties, processes, and/or events that act to result in a phenomenon.
4. Make predictions about the effects of genetic variation from reproduction. Predictions can be made by manipulating model components, completing illustrations, or selecting from lists with distractors.
5. Given models or diagrams of types of reproduction, identify the types of reproduction and how they change in each scenario OR identify the properties of the different types of reproduction that cause genetic variation.
6. Identify missing components, relationships, or other limitations of the model.
7. Identify, calculate, or select the relationships among the components of a model that describe the types of reproduction, the environmental conditions under which reproduction occurs, or explain the genetic variation that results from reproduction.

Performance Expectation MS-LS4-2

Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

Dimensions

Constructing Explanations and Designing Solutions

- Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.

LS4.A: Evidence of Common Ancestry and Diversity

- Anatomical similarities and differences among organisms living today, and between contemporary organisms and those in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.

Patterns

- Patterns can be used to identify cause and effect relationships.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on explanation of the relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.
- Emphasis is on using anatomical similarities and differences to infer relationships among different modern organisms.
- Emphasis is on understanding that the changes over time in the anatomical features seen in fossil records can be used to infer relationships between extinct organisms to living organisms.
- Emphasis is on understanding that organisms that share a pattern of anatomical features are likely to be more closely related than are organisms that do not share a pattern of anatomical features

Content Limits:

- Students do not need to know: name of specific fossil species; knowledge of specific fossils or anatomical features; genetic variation, process of fossil formation, knowledge of geologic time periods; knowledge of rock layer; relationship between fossils and age of rock layers; molecular homology (similarities in DNA, RNA, and protein sequence).

Science Vocabulary Students Are Expected to Know

- homologous
- analogous
- organism
- fossil
- diversity
- extinction
- structure
- radioactive dating
- mineral
- extinct
- unicellular
- multicellular
- organelles
- ancestor
- ancestry
- species
- evolve
- anatomical

Science Vocabulary Students Are Not Expected to Know

- cladogram
- phylogenetic tree
- dichotomous tree
- phylum/phyla
- class
- order
- family
- genus/genera
- divergent
- convergent
- prokaryote
- eukaryote
- types of rock (sedimentary, igneous, metamorphic)
- embyology

Phenomena

Some example phenomena for MS-LS4-2:

- Bats and frogs have forelimbs that look very different, but have similar bones and overall structure.
- Comparing the skull bones of the modern-day whale to the fossilized skulls of Dorudon and Pakicetus, shows a pattern in the position of the nostril as these organisms changed over millions of years.
- Wings are structures that allow most birds to fly, except penguins, which have wings but cannot fly. Modern-day whales live in the ocean but have small hind-legs.

Task Demands Supported by This Performance Expectation and associated Evidence Statements

1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features.
2. Express or complete a causal chain explaining how homologous structures show common ancestry and analogous structures show common function. This may include indicating directions of causality in an incomplete model, such as a flow chart or diagram, or completing cause and effect chains.*(SEP/DCI/CCC)
3. Identify evidence supporting the inference of causation that is expressed in a causal chain.
4. Describe, identify, and/or select information needed to support an explanation.

*denotes those task demands which are deemed appropriate for use in stand-alone item development

Performance Expectation MS-LS4-5

Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.

Dimensions

Obtaining, Evaluating, and Communicating

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and method used, and describe how they are supported or not supported by evidence.

LS4.B: Natural Selection

- In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.

Cause and Effect

- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, and gene therapy) and on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.

Content Limits:

- Students do not need to know: overlapping DNA sequences, Hardy-Weinberg calculations, biodiversity, mechanisms of gene transfer, dominant/recessive genes.

Science Vocabulary Students Are Expected to Know

- natural / artificial selection
- evolution adaptation
- resources reproduction
- offspring breeding Traits
- organisms Genetic engineering
- DNA, cloning
- inherit
- hereditary
- proteins

Science Vocabulary Students Are Not Expected to Know

- chromosomes
- genetic variation
- genetic combination
- meiosis
- mitosis
- replications
- mutations
- gene regulation
- allele
- DNA sequences
- RNA sequences
- amino acid sequences

Phenomena

Some example phenomena for MS-LS4-5:

- Different methods for transferring genes have different rates of success:
- Scientists insert the pGLO plasmid into plants so that the plants glow when they are ready to harvest.
- There is no wild plant that looks like modern corn (soft starchy kernels lined up in a row).
- Farmers isolated wild cabbage plants to create a variety of vegetables, including broccoli and kale. The wild cabbage plants were selected for their different flavors, textures, leaves, and flowers.
- Scientists are currently working to breed sheep that do not burp in order to reduce methane emission.
- Scientists want to breed strong and more resistant bees that won't be damaged by disease and other parasites.
- Scientists have created pest-resistant cotton that is toxic to certain insects that eat the plant.
- Scientists are working to produce drought-resistant sugarcane for farming in dry areas.
- Scientists are working to create animals that have a smaller environmental impact (Enviro-Pig).
- Scientists are working to create plants with immunities to plant diseases.
- Scientists are creating bacteria that produce some specialized substances (insulin, other proteins, medicines).
- Scientists are making animal models of human diseases for study.

Task Demands Supported by This Performance Expectation and associated Evidence Statements

1. Generate or construct tables or assemblages of data that document the similarities and differences between traditional and modern gene selection.
2. Organize and/or arrange data of the success rates of different methods to highlight trends or patterns.
3. Use relationships identified in the data to predict the best gene selection method to use in a given situation.
4. Identify, among distractors, the potential real-world uses of this data.

Performance Expectation MS-PS1-1

Develop models to describe the atomic composition of simple molecules and extended structures.

Dimensions

Developing and Using Models

- Develop and/or use a model to predict and/or describe phenomena.

PS1.A: Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales, using models to study systems that are too large or too small.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on identifying elements vs. compounds and their basic units of atoms and molecules.
- Emphasis is on developing models of molecules that vary in complexity.
- Examples of simple molecules could include ammonia, methanol, methane, water, carbon dioxide, etc.
- Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.

Content Limits:

- Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.
- Modelling should be limited to molecules that have only one type of bond, no combination of bonds; the structure of the molecule is easy to model; single bonded molecules.
- Examples of extended structures could include sodium chloride or diamonds.
- Students are not expected to memorize the atomic characteristics of any element.
- Students do not need to know: valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, a complete description of all individual atoms in a complex molecule or extended structure, memorization of atoms found in different molecule, VSEPR or geometric arrangements, the difference between single, double, and triple bonding, periodic table patterns and how it affects bonding, oxidation numbers, polyatomic ions.

Science Vocabulary Students Are Expected to Know

- atoms
- molecules
- element
- compound
- mixtures
- homogenous
- heterogeneous
- pure substances
- solution
- solvent
- solute

Science Vocabulary Students Are Not Expected to Know

- valence electrons
- subatomic particles such as protons
- electrons
- neutrons
- neutrinos etc.
- ions
- positive or negative charges
- covalent bond
- ionic bond

Phenomena

Some example phenomena for MS-PS1-1:

- Submarines can stay underwater for months using sea water as a source of oxygen for air. Special machines run electricity through large amounts of sea water, generating oxygen from the water.
- Water and hydrogen peroxide are both made up of hydrogen and oxygen. When water is poured on a chunk of $CaCO_3$, there is no reaction. When hydrogen peroxide is poured on a chunk of $CaCO_3$, it fizzes.
- Graphite is an extremely soft substance and diamonds are the hardest substance known. Both are made completely of carbon atoms in different arrangements.
- Oxygen (O_2) is a gas we breathe to stay alive. Ozone (O_3), also made only of oxygen atoms, is unhealthy to breathe.

Task Demands Supported by This Performance Expectation and associated Evidence Statements

1. Identify or assemble from a collection of potential model components, including distractors, components of a model that describes the structures of atoms, molecules, or extended molecules and/or how they interact, or explains how atoms of the same/different element(s) are arranged in repeated patterns in extended structures.
2. Describe, select, and/or identify the relationships among components of a model that describes the structures of atoms, molecules, or extended molecules and/or how they interact, or explains how atoms of the same/different element(s) are arranged in repeated patterns in extended structures.
3. Assemble, illustrate, describe, and/or complete a model or manipulate components of a model to describe the structure of an atom, molecule, or extended molecule and/or how they interact, or to explain or predict how atoms of the same/different element(s) are arranged in repeated patterns in extended structures.

Performance Expectation MS-PS1-2

Analyze and interpret data on the properties of substances before and after the substances interact to determine whether a chemical reaction has occurred.

Dimensions

Analyzing and Interpreting Data

- Analyze and interpret data to determine similarities and differences in findings.

PS1.A: Structure and Properties of Matter

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

PS1.B: Chemical Reactions

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

Patterns

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure.

Clarifications and Content Limits

Clarification Statements:

- Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.

Content Limits:

- Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.
- Students are not expected to balance chemical equations or to determine whether a chemical equation is balanced or not.
- Students are expected to know that mass/matter is neither destroyed nor created.

Science Vocabulary Students Are Expected to Know

- reactant
- product
- atom
- molecule
- compound
- matter
- chemical property
- physical property
- mass
- volume
- density
- melting point
- boiling point
- freezing point
- solubility
- dissolve
- flammability
- odor
- gas
- solid
- liquid
- chemical bonds

Science Vocabulary Students Are Not Expected to Know

- conservation of energy
- collision theory
- oxidation
- reduction
- intramolecular attractions
- intermolecular attractions
- solvent
- solute
- precipitant
- limiting reactant
- excess reactant
- covalent bond
- ionic bond
- rate of chemical reaction
- acid
- base
- salt (as an ionic crystal)
- law of conservation of mass
- fusion
- fission
- homogenous mixture
- heterogeneous mixture

Phenomena

For this performance expectation the phenomena are mixtures of substances that provide sets of data. Those are the observations and/or measurements concerning the physical and chemical properties of the involved substances before and after mixing that the kids will look at to discover patterns. Below, we enumerate some of the mixtures that might provide the data sets to be analyzed.

All phenomenon for this PE should be situations where a chemical reaction is not immediately apparent.

Some example phenomena for MS-PS1-2:

- Rainwater can produce stains on car paint. Reports of these stains are more common in the Southeastern U.S. than they are in the Midwest.
- Steel corrodes when exposed to rainwater. Aluminum exposed to rainwater does not.
- Portions of marble statues that are exposed to rainwater crack and crumble over time. Portions of marble statues that are sheltered develop a black coating over time.
- When sugar crystals are added to vinegar in a bowl, the crystals disappear. When crystals of table salt are added to vinegar in a bowl, the mixture begins to bubble and foam.
- Table sugar exposed to an open flame transforms into a gooey, dark substance. Wood exposed to an open flame transforms into ash

Task Demands Supported by This Performance Expectation and associated Evidence Statements

1. Organize, arrange, and/or generate/construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends, or correlations among observations and data concerning the physical and chemical properties of the substances involved. This may include sorting out distractors.
2. Describe and/or summarize data (e.g., using illustrations and/or labels), to identify/highlight trends, patterns, or correlations among observations and data concerning the physical and chemical properties of the beginning and ending substances being investigated. ***(SEP/DCI/CCC)**
3. Use relationships identified in the data to predict whether the mixing of substances similar to the ones under study will result in the occurrence of a chemical reaction.
4. Identify patterns or evidence in the data that support inferences about any changes that occurred in the microscopic or atomic-level arrangements of the substances involved. ***(SEP/DCI/CCC)**

*denotes those task demands which are deemed appropriate for use in stand-alone item development

Performance Expectation MS-PS1-6

Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

Dimensions

Constructing Explanation and Designing Solutions

- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.

PS1.B: Chemical Reactions

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (secondary)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process-that is, some characteristics may be incorporated into the new design. (secondary)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (secondary)

Energy and Matter

- The transfer of energy can be tracked as energy flows through a designed or natural system.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance.
- Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride

Content Limits:

- Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.
- Students do not need to know.
    - Types of chemical reactions (decomposition, synthesis, single replacement, double replacement, combustion, etc.)
    - How to balance a chemical equation

Science Vocabulary Students Are Expected to Know

- chemical change
- chemical reaction
- reactant
- product
- chemical bond
- compound
- molecule
- solution
- dissolve
- soluble/solubility
- concentration
- chemical potential energy
- thermal energy
- system
- environment
- evaporate
- condense

Science Vocabulary Students Are Not Expected to Know

- endothermic
- exothermic
- precipitant
- solute
- solvent
- crystallization
- dissolution
- polar/polarity
- ion
- intermolecular force
- intramolecular force
- enthalpy
- entropy
- heat of solution
- heat of reaction
- microstates
- equilibrium
- saturate/saturation

Phenomena

Some example design projects for MS-PS1-6:

- Design a sport's injury pack that when used, will heat and soothe sore muscles.
- Design a sport's injury cold pack that will help prevent swelling.
- Design a self-heating pad that can warm ready-to-eat meal.
- Design a device that can be used to keep electronics like computers from overheating.

Task Demands Supported by This Performance Expectation and associated Evidence Statements

1. Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features.
2. Express or complete a causal chain explaining the chemical processes that resulted in the release or absorption of thermal energy. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause and effect chains.
3. Describe, identify, and/or select evidence supporting the inference of causation that is expressed in a causal chain and/or an explanation of the processes that cause the observed results.
4. Use an explanation to predict the direction or the relative magnitude of a change in thermal energy of a chemical system, given a change in the amount/concentration of chemical substances in the system, the temperature of the substances in the system, and/or the amount of time the substances interact in the system.
5. Identify or assemble from a collection, including distractors, the relevant aspects of the problem that given design solutions, if implemented, will resolve/improve.
6. Using the given information, select or identify the criteria against which the device or solution should be judged.
7. Using given data, propose/illustrate/assemble a potential device (prototype) or solution.
8. Using a simulator, test a proposed prototype and evaluate the outcomes, potentially including proposing and testing modifications to the prototype.

Performance Expectation MS-PS2-1

Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic level.

Dimensions

Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

PS2.A: Forces and Motion

- Newton’s second law accurately predicts changes in the motion of macroscopic things..

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Clarifications and Content Limits

Clarification Statements:

- Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.

Content Limits:

- Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.
- Stating the law or naming the law is not part of this PE.

Science Vocabulary Students Are Expected to Know Attraction

- velocity
- acceleration
- net force
- friction
- air resistance
- impulse
- vectors
- slope
- y-intercept

Science Vocabulary Students Are Not Expected to Know

- terminal velocity

Phenomena

The phenomenon for these PEs are the given data. Samples of phenomena should describe the data set(s) to be given in terms of patterns or relationships to be found in the data, and the columns and rows of a hypothetical table presenting the data, even if the presentation is not tabular. The description of the phenomenon should describe the presentation format of the data (e.g., maps, tables, graphs, etc).

Some example phenomena for MS-PS2-1:

- Force is removed from two vehicles’ accelerator pedals. The vehicles’ positions over time are given.
- A water tank railcar is pulled by a train engine at constant speed and develops a leak allowing water to escape. The position and velocities of the water tank and train over time are given.
- A heavy model rocket rises a shorter distance than a lighter model rocket using the same type of engine. The position of each rocket over time is given.
- A falling skydiver’s velocity increases for several minutes and then reaches a maximum speed. The velocity of the skydiver over time is given.

Task Demands Supported by This Performance Expectation and associated Evidence

1. Organize and/or arrange (e.g., using illustrations and/or labels), make calculations or summarize data to highlight trends, patterns, or correlations.
2. Generate/construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends or relationships in the motion of a macroscopic object. This may include sorting out distractors.
3. Construct, state, or select a claim or propose a design solution based on the relationships identified in the data.
4. Use relationships identified in the data to predict the motion of and changes in the motion of macroscopic objects.
5. Identify patterns or evidence in the data that supports inferences about the motion of and changes in the motion of macroscopic objects.

Performance Expectation MS-PS2-3

Ask questions about data to determine the factors that affect the strength of electrical and magnetic forces.

Dimensions

Asking Questions and Defining Problems

- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.

PS2.B: Types of Interactions

- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Clarifications and Content Limits

Clarification Statements:

- Examples could include electromagnets, electric motors, or generators.
- Examples of data could include the effect of the number or turns of wire on the strength of an electromagnet, or of increasing the number or strength of magnets on the speed of an electric motor.

Content Limits:

- Quantitative responses are limited to proportional reasoning and algebraic thinking.

Science Vocabulary Students Are Expected to Know Attraction

- charge
- conductor
- electric charge
- electric current
- electric field
- electric force
- electromagnetic field
- electromagnet
- frequency
- induction
- insulator
- magnetic field
- magnetic field lines
- magnetic force
- permanent magnet
- polarity
- repulsion
- resistance
- voltage

Science Vocabulary Students Are Not Expected to Know

- Lorentz force
- electric potential
- electromotive force

Phenomena

Some example phenomena for MS-PS2-3:

- A radio emits music from its speakers. After a magnet in the speakers is removed, no sound can be heard.
- More electrical current is produced by a windmill when the wind speed is greater.
- Merchandise from a store that uses electromagnetic anti-shoplifting devices will set off an alarm at the exit if the tag is not removed.
- An electromagnet at a junkyard can lift old cars, while a homemade electromagnet cannot pick up much more than a few paper clips.

Task Demands Supported by This Performance Expectation and associated Evidence

1. Make and/or record observations about the factors that affect electromagnets, electric motors, or generators.
2. Organize and/or arrange (e.g., using illustrations and/or labels), or summarize data to highlight trends, patterns, or correlations.
3. Generate/construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends, or correlations in the factors that affect the strength of electric and magnetic forces. This may include sorting out distractors.
4. Explain or describe the causal processes that lead to the observed data.
5. Use relationships identified in the data to predict the strength of electric and/or magnetic forces.

Performance Expectation MS-PS4-1

Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

Dimensions

Using Mathematics and Computational Thinking

- Use mathematical representations to describe and/or support scientific conclusions and design solutions.

PS4.A: Wave Properties

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

Patterns

- Graphs and charts can be used to identify patterns in data.

Clarifications and Content Limits

Clarification Statements:

- Emphasize describing waves with both quantitative and qualitative thinking.
- Examples could include using graphs, charts, computer simulations, or physical models to demonstrate amplitude and energy correlation.
- All equations and formulas must be provided and be age-appropriate.

Content Limits:

- Assessment does not include electromagnetic waves and is limited to standard repeating waves.
- Assessment does not include identifying or knowing characteristics of different types of waves (mechanical, electromagnetic, sonic, etc.).
- Students do not need to know: how two waves carrying the same energy can have different amplitudes when introduced into materials of different densities and elasticities.

Science Vocabulary Students Are Expected to Know

- speed
- force
- kinetic energy
- proportional
- sound wave
- wavelength
- frequency
- resting position
- medium

Science Vocabulary Students Are Not Expected to Know

- elastic
- seismic wave
- crest
- trough
- oscillate

Phenomena

Some example phenomena for MS-PS4-1:

- The 1896 Sanriku earthquake off the coast of Japan generated ocean waves that reached a height of 100 feet (30 m).
- Compared to a megaphone that sends sound messages up to 300 meters away, a Long Range Acoustic Device (LRAD) sends messages that can be heard up to 5,500 meters away.
- Scientists at the Swiss Federal Institute in Zurich caused a toothpick to levitate using sound waves.
- A wave travels down a rope from one student to another when the first student shakes it.

Task Demands Supported by This Performance Expectation and associated Evidence Statements

1. Compile and analyze data to make an inference about the relationship between amplitude and energy of a wave. This may include sorting out relevant from irrelevant data in the given information.
2. Organize and/or arrange (e.g., using illustrations and/or labels) or summarize data to highlight trends, patterns, or correlations that reflect how energy changes with amplitude of a wave and vice versa.
3. Identify how wave characteristics correspond to physical observations (e.g., wave amplitude corresponds to sound volume).
4. Use relationships identified in the data to predict the energy or amplitude change of a wave if the other parameter is changed.
5. Based on data, calculate or estimate one property of a wave (energy or amplitude) and the relationships between different properties of a wave.
6. Use graphs, charts, simulations, or physical models to demonstrate amplitude and energy correlation.

Performance Expectation MS-PS4-2

Develop and/or use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Dimensions

Developing and Using Models

- Develop and/or use a model to predict and/or describe phenomena.

PS4.A: Wave Properties

- A sound wave needs a medium through which it is transmitted.

PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass), where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Structure and Function

- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

Clarifications and Content Limits

Clarification Statements:

- Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.
- This includes amplitudes, frequencies, and wave lengths.

Content Limits:

- Assessment is limited to qualitative applications pertaining to light and mechanical waves.
- Qualitative models, not quantitative.
- Particle movement and compression waves are not to be assessed at this level.
- Constructive/destructive interference are not to be assessed.

Science Vocabulary Students Are Expected to Know

- reflected
- absorbed
- transmitted
- refracted
- medium
- transparent
- frequency
- brightness
- color
- bending
- amplitude
- sound wave
- light wave
- path
- propagation
- matter
- filter
- barrier
- lens
- mirror
- mechanical waves
- electromagnetic
- visible light
- ray
- prism
- wavelength

Science Vocabulary Students Are Not Expected to Know

- longitudinal wave
- transverse wave
- compression wave
- seismic wave
- radio wave
- microwave
- infrared
- ultraviolet
- X-rays
- gamma rays
- angle of incidence
- concave
- convex
- diffraction
- constructive interference
- destructive interference

Phenomena

Some example phenomena for MS-PS4-2:

- One part of a straw appears to be broken from the rest of the straw when viewed through the side of a glass of water.
- Music placed near a lake can be heard clearly while sitting on the shore. However, while swimming under the water, the sound cannot be heard as clearly.
- Objects are more visible during a moonlit night when there is snow on the ground vs. when there is no snow on the ground.
- Loud music moves the leaves of a plant.
- Whisper Corners in the Capitol Building.

Task Demands Supported by This Performance Expectation and associated Evidence Statements

1. Select from a collection of potential model components including distractors, the components needed to model the phenomenon. Components might include type of wave, properties of the wave, the materials with which the waves interact, the position of the source of the wave, etc.
2. Assemble, from a collection of potential model components, an illustration or flow chart that is capable of representing the movement, transmission, reflection, refraction, and absorption of waves. This does not include labeling an existing diagram.
3. Manipulate the components of a model to demonstrate the changes that cause the observed phenomenon.
4. Manipulate the components of a model to predict the behavior of waves in an alternate scenario.
5. Given models or diagrams of how a wave interacts with different materials, identify the wave properties and how they change in each scenario OR identify the properties of the different materials that cause the wave to behave differently.
6. Identify missing components, relationships, or other limitations of the model.