# Amherst County Public Schools
## $8^{th}$ Grade Science Curriculum Pacing Guide

REV: 8/12

<table>
<tr><th>1st 9 weeks</th><th>SOL Objectives</th><th>Vocabulary</th></tr>
<tr><td colspan="2">
6.1, LS.1, PS. 1 The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which<br>
a)observations are made involving fine discrimination between similar objects and organisms;<br>
b) precise and approximate measurements are recorded; length, mass, volume, density, temperature, weight, and force are accurately measured and reported using the International system of Units;<br>
c) scale models are used to estimate distance, volume, and quantity;<br>
d) hypotheses are stated in ways that identify the independent and dependent variables and constants:<br>
e) a method is devised to test the validity of predictions and inferences;<br>
f) one variable is manipulated over time, using many repeated trials;<br>
g) data are collected, recorded, analyzed and reported using metric measurements and tools;<br>
h) data are analyzed and communicated through graphical representation and tables, scattergrams, line plots and histograms are constructed and interpreted; predictions are made from this data;<br>
i)models and simulations are designed and used to illustrate and explain phenomena and systems;<br>
j) current applications are used to reinforce science concepts;<br>
k) sources of experimental error are identified;<br>
l) interpretations from a set of data are evaluated and defended; valid conclusions are made after analyzing data:<br>
m) conversions are made among metric units applying appropriate prefixes;<br>
n) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders and spring scales are used to gather data;<br>
o) numbers are expressed in scientific notation where appropriate;<br>
p) research skills are utilized using a variety of resources;<br>
q) data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted;<br>
15 days<br>
RESOURCES: 6.1 LS.1 PS.1
</td><td>
Independent variable<br>
Dependent variable<br>
Controlled experiment<br>
Control group<br>
Experimental error<br>
Hypothesis, Procedure<br>
Data, Analyze<br>
Conclude, Meter<br>
Millimeter, Centimeter<br>
Liter, Milliliter<br>
Milligram, Gram<br>
Kilogram, SI<br>
Constants, Data table<br>
Qualitative, Quantitative<br>
Convert<br>
Balances<br>
Graduated cylinders<br>
Spring scales<br>
Scientific notation<br>
Central tendency<br>
Range<br>
Frequency<br>
Scattergram<br>
Histogram<br>
Observational<br>
Experimental<br>
Evaluate<br>
Credibility<br>
Mass<br>
Density<br>
Weight<br>
Volume<br>
Force<br>
Cubic centimeters<br>
Celcius<br>
Newton
</td></tr>
</table>

| | |
|---|---|
| **6.4, PS.2, PS.3, Atoms**<br>a) Atoms consist of particles, including electrons, protons and neutrons;<br>b) Atoms of a particular element are alike but are different from atoms of other elements;<br>c) Elements may be represented by chemical symbols;<br>d) Two or more atoms interact to form new substances, which are held together by electrical forces (bonds);<br>e) Compounds may be represented by chemical changes;<br>f) A limited number of elements comprise the largest portion of the solid Earth, living matter, the oceans and the atmosphere;<br>g) The particle theory of matter;<br>h) Solids, liquids and gases;<br>i) Characteristics of types of matter based on physical and chemical properties;<br>j) Physical properties ( shape, density, solubility, odor, melting point, boiling point, color );<br>k) Chemical properties ( combustibility, reactivity)<br>l) Contributions of Dalton, Thomson, Rutherford, and Bohr in understanding the atom;<br>m) The modern model of atomic structure;<br>**10 days**<br>**RESOURCES: 6.4 PS.2 PS.3** | Nucleus<br>Protons<br>Neutrons<br>Electrons<br>Elements<br>Compounds |
| **PS.4 Periodic Table of Elements**<br>a) Symbols, atomic number, atomic mass, chemical families ( groups), periods;<br>b) Classification of elements as metals, metalloids, and nonmetals; and<br>c) Simple compounds (formulas and nature of bond<br>**5 days**<br>**RESOURCES: PS.4** | Periodic table<br>Formula<br>Equation<br>Atom |

| | |
|---|---|
| **PS.5 The student will investigate and understand changes in matter and the relationship of these changes to the Law of Conservation of Matter and Energy. Key concepts include**<br>a)physical changes<br>b) nuclear reactions (products of fusion and fission and their effects on human beings and the environment) and<br>c) chemical changes (types of reactions, reactants and products, and balanced equations)<br>d) acids, bases, salts, acidity, basicity<br>**10 days**<br>**RESOURCES: PS.5** | Matter mixture<br>Acid<br>Bases<br>Salts<br>Inorganic<br>Organic<br>Ions<br>Physical properties<br>Chemical properties<br>Combustibility<br>Reactivity<br>Solubility<br>Melting point<br>Boiling Point |

| 2nd 9 Weeks | SOL Objectives | Vocabulary |
|---|---|---|
| **PS.7 The students will investigate and understand temperature scales, heat and heat transfer. Key concepts include**<br>a) Celsius and Kelvin temperature scales and absolute zero;<br>b) Phase change, freezing point, melting point, boiling point, vaporization, and condensation;<br>c) Conduction, convection and radiation, and<br>d) Applications of heat transfer (heat engines, thermostats, refrigeration, and heat pumps).<br>**10days**<br>**RESOURCES: PS.7** | | Celsius<br>Kelvin<br>Absolute zero<br>Freezing point<br>Vaporization<br>Condensation<br>Conduction<br>Convection<br>Radiation<br>Physical properties<br>Salability<br>Chemical properties<br>Combustibility<br>Reactivity<br>Ionic bond<br>Covalent bond<br>Atomic number<br>Atomic mass<br>Valence<br>Metalloids<br>Metals<br>Nonmetals<br>Balanced equations<br>Symbols (chemical)<br>Chemical families<br>Simple compounds |
| **6.2 The student will investigate and understand basic sources of energy, their origins, transformations and uses. Key concepts include**<br>a) Potential and kinetic energy;<br>b) The role of the sun in the formation of most energy sources on Earth;<br>c) Nonrenewable energy sources;<br>d) Renewable energy sources; and<br>e) Energy transformations<br>**10 days**<br>**RESOURCES: 6.2** | | |

| | |
|---|---|
| **PS.6 The students will investigate and understand states and forms of energy and how energy is transferred and transformed. Key concepts include**<br>a) Mechanical, chemical and electrical energy; and<br>b) Heat, light and nuclear.<br>**10 days**<br>**RESOURCES: PS.6** | Acids, bases, salts<br>Acidity<br>Basicity<br>Nuclear reactions, Fusion<br>Fission<br>Reactants<br>Products |
| **PS.10 The student will investigate and understand scientific principles and technological applications of work, force, and motion. Key concepts include**<br>a) Speed, velocity and acceleration;<br>b) Newton's laws of motion;<br>c) Work, force, mechanical advantage, efficiency, and power; and<br>d) Applications (simple machines, compound machines, powered vehicles, rockets and retraining devices).<br>**10 days**<br>**RESOURCES PS.10** | Speed, Velocity, Acceleration<br>Newton's laws of motion<br>Work, Force<br>Mechanical advantage<br>Efficiency, Power<br>Simple machines<br>Compound machines<br>Powered vehicles<br>Rockets, Retraining devices<br>Potential energy<br>Kinetic energy<br>Thermal, Radiant,<br>Mechanical, Electrical<br>Hydroelectric |

| 3rd Nine weeks SOL Objectives | Vocabulary |
| --- | --- |
| **6.3The student will investigate and understand the role of solar energy in driving most natural processes within the atmosphere, the hydrosphere, and on Earth's surface. Key concepts include**<br>c) the motion of the atmosphere and the oceans;<br>d) cloud formation; and<br>e) the role of thermal energy in weather-related phenomena including thunderstorms and hurricanes.<br>**5 days**<br>**RESOURCES 6.3** | Atmosphere, Hydrosphere<br>Thermal energy<br>universal solvent<br>physical weathering<br>chemical weathering,<br>agriculture<br>elements, compounds<br>pressure, temperature<br>humidity, altitude<br>fronts, systems, ecosystems |
| **6.5The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include**<br>a) water as the universal solvent;<br>b) the properties of water in all three phases;<br>c) the action of water in physical and chemical weathering;<br>d) the ability of large bodies of water to store thermal energy and moderate climate;<br>e) the importance of water for agriculture, power generation, and public health; and<br>f) the importance of protecting and maintaining water resources.<br>**5 days**<br>**RESOURCES 6.5** | abiotic factors<br>divides, tributaries<br>river systems<br>wetlands |
| **6.6 The student will investigate and understand the properties of air and the structure and dynamics of Earth's atmosphere. Key concepts include**<br>a) air as a mixture of gaseous elements and compounds;<br>b) pressure, temperature, and humidity;<br>c) atmospheric changes with altitude;<br>d) natural and human-caused changes to the atmosphere and the importance of protecting and maintaining air quality;<br>e) the relationship of atmospheric measures and weather conditions; and<br>f) basic information from weather maps, including fronts, systems, and basic measurements.<br>**5 days**<br>**RESOURCES 6.6** | |

| | |
|---|---|
| **6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include**<br>a) the health of ecosystems and the abiotic factors of a watershed;<br>b) the location and structure of Virginia's regional watershed systems;<br>c) divides, tributaries, river systems, and river and stream processes;<br>d) wetlands;<br>e) estuaries;<br>f) major conservation, health, and safety issues associated with watersheds; and<br>water monitoring and analysis using field equipment including hand-held technology.<br>**5 days**<br>**RESOURCES 6.7** | Estuaries<br>Conservation<br>Watershed<br>terrestrial ecosystem<br>marine ecosystems |
| **6.9 The student will investigate and understand public policy decisions relating to the environment. Key concepts include**<br>a) management of renewable resources;<br>b) management of nonrenewable resources;<br>c) the mitigation of land-use and environmental hazards through preventive measures; and<br>cost/benefit tradeoffs in conservation policies.<br>**5 days**<br>**RESOURCES 6.9** | renewable resources<br>nonrenewable resources<br>mitigation<br>environment |
| **LS.5 The student will investigate and understand the basic physical and chemical processes of photosynthesis and its importance to plant and animal life. Key concepts include**<br>a) energy transfer between sunlight and chlorophyll;<br>b) transformation of water and carbon dioxide into sugar and oxygen; and<br>c) photosynthesis as the foundation of virtually all food webs.<br>**2 days**<br>**RESOURCES LS.5** | photosynthesis<br>chlorophyll<br>transformation |

| | |
|---|---|
| **LS.6 The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment. Key concepts include**<br>a) the carbon, water, and nitrogen cycles;<br>b) interactions resulting in a flow of energy and matter throughout the system;<br>c) complex relationships within terrestrial, freshwater, and marine ecosystems; and<br>d) energy flow in food webs and energy pyramids.<br>**2 days**<br>**RESOURCES LS.6** | terrestrial ecosystem<br>marine ecosystems<br>food web<br>energy pyramids |
| **LS.7 The student will investigate and understand that interactions exist among members of a population. Key concepts include**<br>a) competition, cooperation, social hierarchy, territorial imperative; and<br>b) influence of behavior on a population.<br>**2 days**<br>**RESOURCES LS.7** | competition<br>cooperation<br>social hierarchy territorial imperative<br>population |
| **LS.8 The student will investigate and understand interactions among populations in a biological community. Key concepts include**<br>a) the relationships among producers, consumers, and decomposers in food webs;<br>b) the relationship between predators and prey;<br>c) competition and cooperation;<br>d) symbiotic relationships; and<br>e) niches.<br>**3 days**<br>**RESOURCES LS.8** | producers<br>consumers<br>decomposers<br>predators<br>prey<br>competition<br>cooperation<br>symbiotic relationships<br>niche |

| | |
|---|---|
| **LS.9 The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem. Key concepts include**<br>a) differences between ecosystems and biomes;<br>b) characteristics of land, marine, and freshwater ecosystems; and<br>c) adaptations that enable organisms to survive within a specific ecosystem.<br>**2 days**<br>**RESOURCES LS.9** | Ecosystem<br>Biome<br>Communities<br>Populations<br>Dynamic |
| **LS.10 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic, change over time, and respond to daily, seasonal, and long-term changes in their environment. Key concepts include**<br>a) phototropism, hibernation, and dormancy;<br>b) factors that increase or decrease population size; and<br>c) eutrophication, climate changes, and catastrophic disturbances.<br>**2 days**<br>**RESOURCES LS.10** | phototropism hibernation<br>dormancy<br>eutrophication<br>climate changes catastrophic<br>disturbances<br>competition |
| **LS.11 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include**<br>a) food production and harvest;<br>b) change in habitat size, quality, or structure;<br>c) change in species competition;<br>d) population disturbances and factors that threaten or enhance species survival; and<br>environmental issues<br>**2 days**<br>**RESOURCES LS.11** | |

| 4th Nine Weeks | SOL Objectives | Vocabulary |
| --- | --- | --- |
| **6.8 The student will investigate and understand the organization of the solar system and the interactions among the various bodies that comprise it. Key concepts include**<br>a) the sun, moon, Earth, other planets and their moons, dwarf planets, meteors, asteroids, and comets;<br>b) relative size of and distance between planets;<br>c) the role of gravity;<br>d) revolution and rotation;<br>e) the mechanics of day and night and the phases of the moon;<br>f) the unique properties of Earth as a planet;<br>g) the relationship of Earth's tilt and the seasons;<br>h) the cause of tides; and<br>i) the history and technology of space exploration.<br>**20 days**<br>**RESOURCES 6.8** | | solar system<br>sun<br>moon<br>Earth<br>dwarf planets<br>meteors<br>asteroids<br>comets<br>gravity<br>revolution<br>rotation<br>phases<br>tilt<br>tides<br>space exploration |
| **LS.2 The student will investigate and understand that all living things are composed of cells. Key concepts include**<br>a) cell structure and organelles;<br>b) similarities and differences between plant and animal cells;<br>c) development of cell theory; and<br>d) cell division.<br>**3 days**<br>**RESOURCES LS.2** | | cells<br>cell structure<br>organelles<br>plant cell<br>animal cell<br>cell theory<br>cell division |

| | |
|---|---|
| **LS.3 The student will investigate and understand that living things show patterns of cellular organization. Key concepts include**<br>a) cells, tissues, organs, and systems; and<br>b) patterns of cellular organization and their relationship to life processes in living things.<br>**2 days**<br>**RESOURCES LS.3** | cellular organization<br>tissues<br>organs<br>organ systems |
| **LS.12 The student will investigate and understand that organisms reproduce and transmit genetic information to new generations. Key concepts include**<br>a) the structure and role of DNA;<br>b) the function of genes and chromosomes;<br>c) genotypes and phenotypes;<br>d) characteristics that can and cannot be inherited;<br>e) genetic engineering and its applications; and<br>f) historical contributions and significance of discoveries related to genetics.<br>**4 days**<br>**RESOURCES LS.12** | organism<br>DNA<br>Genes<br>Chromosomes |
| **LS.13 The student will investigate and understand that populations of organisms change over time. Key concepts include**<br>a) the relationships of mutation, adaptation, natural selection, and extinction;<br>b) evidence of evolution of different species in the fossil record; and<br>c) how environmental influences, as well as genetic variation, can lead to diversity of organisms.<br>**3 days**<br>**RESOURCES LS.13** | |

| | |
|---|---|
| **PS.8 The student will investigate and understand the characteristics of sound waves. Key concepts include**<br>a) wavelength, frequency, speed, amplitude, rarefaction, and compression;<br>b) resonance;<br>c) the nature of compression waves; and technological applications of sound.<br>**2 days**<br>**RESOURCES PS.8** | sound waves<br>wavelength<br>frequency<br>speed<br>amplitude<br>rarefaction<br>compression<br>resonance |
| **PS.9 The student will investigate and understand the characteristics of transverse waves. Key concepts include**<br>a) wavelength, frequency, speed, amplitude, crest, and trough;<br>b) the wave behavior of light;<br>c) images formed by lenses and mirrors;<br>d) the electromagnetic spectrum; and technological applications of light<br>**3 days**<br>**RESOURCES PS.9** | transverse waves<br>crest<br>trough<br>electromagnetic spectrum |
| **PS.11 The student will investigate and understand basic principles of electricity and magnetism. Key concepts include**<br>a) static electricity, current electricity, and circuits;<br>b) relationship between a magnetic field and an electric current;<br>c) electromagnets, motors, and generators and their uses; and<br>d) conductors, semiconductors, and insulators.<br>**3 days**<br>**RESOURCES PS.11** | magnetism<br>static electricity<br>current electricity<br>circuits<br>magnetic field<br>electric current<br>electromagnets<br>motors<br>generators<br>conductors<br>semiconductors<br>insulators |

**Science Standards of Learning**

# Curriculum Framework 2010

## Grade Six

# Virginia *Science Standards of Learning* Curriculum Framework 2010

## Introduction

The *Science Standards of Learning* Curriculum Framework amplifies the *Science Standards of Learning for Virginia Public Schools* and defines the content knowledge, skills, and understandings that are measured by the Standards of Learning tests. The Science Curriculum Framework provides additional guidance to school divisions and their teachers as they develop an instructional program appropriate for their students. It assists teachers as they plan their lessons by identifying essential understandings and defining the essential content knowledge, skills, and processes students need to master. This supplemental framework delineates in greater specificity the minimum content that all teachers should teach and all students should learn.

School divisions should use the *Science Curriculum Framework* as a resource for developing sound curricular and instructional programs. This framework should not limit the scope of instructional programs. Additional knowledge and skills that can enrich instruction and enhance students' understanding of the content identified in the Standards of Learning should be included as part of quality learning experiences.

The Curriculum Framework serves as a guide for Standards of Learning assessment development. Assessment items may not and should not be a verbatim reflection of the information presented in the Curriculum Framework. Students are expected to continue to apply knowledge and skills from Standards of Learning presented in previous grades as they build scientific expertise.

The Board of Education recognizes that school divisions will adopt a K–12 instructional sequence that best serves their students. The design of the Standards of Learning assessment program, however, requires that all Virginia school divisions prepare students to demonstrate achievement of the standards for elementary and middle school by the time they complete the grade levels tested. The high school end-of-course Standards of Learning tests, for which students may earn verified units of credit, are administered in a locally determined sequence.

Each topic in the *Science Standards of Learning* Curriculum Framework is developed around the Standards of Learning. The format of the Curriculum Framework facilitates teacher planning by identifying the key concepts, knowledge and skills that should be the focus of instruction for each standard. The Curriculum Framework is divided into two columns: Understanding the Standard (K-5); Essential Understandings (middle and high school); and Essential Knowledge, Skills, and Processes. The purpose of each column is explained below.

*Understanding the Standard (K-5)*

This section includes background information for the teacher. It contains content that may extend the teachers' knowledge of the standard beyond the current grade level. This section may also contain suggestions and resources that will help teachers plan instruction focusing on the standard.

*Essential Understandings (middle and high school)*

This section delineates the key concepts, ideas and scientific relationships that all students should grasp to demonstrate an understanding of the Standards of Learning.

*Essential Knowledge, Skills and Processes (K-12)*

Each standard is expanded in the Essential Knowledge, Skills, and Processes column. What each student should know and be able to do in each standard is outlined. This is not meant to be an exhaustive list nor a list that limits what is taught in the classroom. It is meant to be the key knowledge and skills that define the standard.

## Grade Six
## Science Strand

# Scientific Investigation, Reasoning, and Logic

This strand represents a set of inquiry skills that defines what a student will be able to do when conducting activities and investigations. The various skill categories are described in the "Investigate and Understand" section of the Introduction to the *Science Standards of Learning*, and the skills in science standards 6.1 represent more specifically what a student should be able to do as a result of science experiences in sixth grade. Across the grade levels, the skills in the "Scientific Investigation, Reasoning, and Logic" strand form a nearly continuous sequence of investigative skills. It is important that the classroom teacher understand how the skills in standard 6.1 are a key part of this sequence (i.e., K.1, K.2, 1.1, 2.1, 3.1, 4.1, and 5.1). The sixth-grade curriculum should ensure that skills from preceding grades are continuously reinforced and developed.

6.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

a) observations are made involving fine discrimination between similar objects and organisms;
b) precise and approximate measurements are recorded;
c) scale models are used to estimate distance, volume, and quantity;
d) hypotheses are stated in ways that identify the independent and dependent variables;
e) a method is devised to test the validity of predictions and inferences;
f) one variable is manipulated over time, using many repeated trials;
g) data are collected, recorded, analyzed, and reported using metric measurements and tools;
h) data are analyzed and communicated through graphical representation;
i) models and simulations are designed and used to illustrate and explain phenomena and systems; and
j) current applications are used to reinforce science concepts.

## Overview

The skills described in standard 6.1 are intended to define the "investigate" component of all of the other sixth-grade standards (6.2–6.9). The intent of standard 6.1 is that students will continue to develop a range of inquiry skills and achieve proficiency with those skills in the context of the concepts developed at the sixth grade. Standard 6.1 does not require a discrete unit on scientific investigation because the inquiry skills that make up the standard should be incorporated in all the other sixth-grade standards. It is also intended that by developing these skills, students will achieve greater understanding of scientific inquiry and the nature of science, as well as more fully grasp the content-related concepts in the standards. It is also intended that models, simulations and current applications are used throughout the course in order to learn and reinforce science concepts.

6.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

a) observations are made involving fine discrimination between similar objects and organisms;
b) precise and approximate measurements are recorded;
c) scale models are used to estimate distance, volume, and quantity;
d) hypotheses are stated in ways that identify the independent and dependent variables;
e) a method is devised to test the validity of predictions and inferences;
f) one variable is manipulated over time, using many repeated trials;
g) data are collected, recorded, analyzed, and reported using metric measurements and tools;
h) data are analyzed and communicated through graphical representation;
i) models and simulations are designed and used to illustrate and explain phenomena and systems; and
j) current applications are used to reinforce science concepts.

## Essential Understandings

The concepts developed in this standard include the following:

- The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world. The nature of science includes the following concepts
  a) the natural world is understandable;
  b) science is based on evidence, both observational and experimental;
  c) science is a blend of logic and innovation;
  d) scientific ideas are durable yet subject to change as new data are collected;
  e) science is a complex social endeavor; and
  f) scientists try to remain objective and engage in peer review to help avoid bias.
- To communicate an observation accurately, one must provide critical details of exactly what is being observed. Using that information, students will be able to differentiate definitively between or among similar objects and/or organisms.
- Systematic investigations require accurate measurements; however, in the absence of precision tools, observers must record careful

## Essential Knowledge, Skills, and Processes

In order to meet this standard, it is expected that students will

- make connections between the components of the nature of science and their investigations and the greater body of scientific knowledge and research.
- make observations that can be used to discriminate similar objects and organisms, paying attention to fine detail.
- make precise and consistent measurements and estimations.
- create approximate scale models to demonstrate an understanding of distance, volume, and quantity.
- differentiate between independent and dependent variables in a hypothesis.
- propose hypotheses or predictions from observed patterns.
- compare and contrast predictions and inferences. Analyze and judge the evidence, observations, scientific principles, and data used in making predictions and inferences.
- design an experiment in which one variable is manipulated over many trials.

6.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

a) observations are made involving fine discrimination between similar objects and organisms;
b) precise and approximate measurements are recorded;
c) scale models are used to estimate distance, volume, and quantity;
d) hypotheses are stated in ways that identify the independent and dependent variables;
e) a method is devised to test the validity of predictions and inferences;
f) one variable is manipulated over time, using many repeated trials;
g) data are collected, recorded, analyzed, and reported using metric measurements and tools;
h) data are analyzed and communicated through graphical representation;
i) models and simulations are designed and used to illustrate and explain phenomena and systems; and
j) current applications are used to reinforce science concepts.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| estimations.<br>• Scale models must maintain relative values of size and/or quantity in order to maintain the integrity of the object or topic being modeled.<br>• An experiment is a structured test of a hypothesis. A hypothesis is stated in terms of a testable relationship.<br>• A scientific prediction is a forecast about what may happen in some future situation. It is based on the application of scientific principle and factual information.<br>• An inference is an explanation based on observations and background knowledge. A conclusion is formulated from collected data. For example, one might observe darkly colored pond water and make the inference that it is polluted. However, only after data are collected can a conclusion be formulated.<br>• Patterns discerned from direct observations can be the basis for predictions or hypotheses that attempt to explain the mechanism responsible for the pattern.<br>• Accurate observations and evidence are necessary to draw realistic and plausible conclusions.<br>• In order to conduct an experiment, one must recognize all of the potential variables that can affect an outcome. | • collect, record, analyze, and report data, using metric terminology and tools.<br>• analyze and communicate data, using graphs (bar, line, and circle), charts, and diagrams.<br>• design a model that explains a sequence, for example, the sequence of events involved in the formation of a cloud. |

6.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

a) observations are made involving fine discrimination between similar objects and organisms;
b) precise and approximate measurements are recorded;
c) scale models are used to estimate distance, volume, and quantity;
d) hypotheses are stated in ways that identify the independent and dependent variables;
e) a method is devised to test the validity of predictions and inferences;
f) one variable is manipulated over time, using many repeated trials;
g) data are collected, recorded, analyzed, and reported using metric measurements and tools;
h) data are analyzed and communicated through graphical representation;
i) models and simulations are designed and used to illustrate and explain phenomena and systems; and
j) current applications are used to reinforce science concepts.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| • In a scientific investigation, data should be collected, recorded, analyzed, and reported using appropriate metric measurement and tools.<br>• In a scientific investigation, data should be organized and communicated through appropriate graphical representation (graph, chart, table, and diagram).<br>• Models provide a way of visually representing abstract concepts. The use of models permits students to order events or processes.<br>• Science concepts are applied through observations and connections with everyday life and technology. | |

# Force, Motion, and Energy

The strand focuses on student understanding of what force, motion, and energy are and how the concepts are connected. The major topics developed in this strand include magnetism; types of motion; simple machines; and energy forms and transformations, especially electricity, sound, and light. This strand includes science standards K.3, 1.2, 2.2, 3.2, 4.2, 4.3, 5.2, 5.3, 6.2, and 6.3.

| | |
|---|---|
| 6.2 | The student will investigate and understand basic sources of energy, their origins, transformations, and uses. Key concepts include<br>a) potential and kinetic energy;<br>b) the role of the sun in the formation of most energy sources on Earth;<br>c) nonrenewable energy sources;<br>d) renewable energy sources; and<br>e) energy transformations. |

## Overview

Many sources of energy on Earth are the result of solar radiation. This can be energy Earth is currently receiving or energy that has been stored as fossil fuels. All energy exists in two basic forms — kinetic and potential. Understanding the forms of energy and their transformations will provide the foundation for students to investigate the transfer of energy within living and Earth systems as well as to understand chemical reactions, force, and motion. This standard builds upon concepts of energy sources introduced in science standard 3.11. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.

6.2 The student will investigate and understand basic sources of energy, their origins, transformations, and uses. Key concepts include

a) potential and kinetic energy;
b) the role of the sun in the formation of most energy sources on Earth;
c) nonrenewable energy sources;
d) renewable energy sources; and
e) energy transformations.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Potential energy is energy that is not "in use" and available to do work. Kinetic energy is energy that is "in use" — the energy a moving object has due to its motion. For example, moving water and wind have kinetic energy. The chemical energy in fossil fuels is potential energy until it is released.<br>• Solar energy from the ancient past is stored in fossil fuels, such as coal, petroleum, and natural gas. Fossil fuels are rich in the elements carbon and hydrogen. These sources of energy take very long periods of time to form and once depleted, are essentially nonrenewable. Nuclear power is also a source of nonrenewable energy.<br>• Many of Earth's energy resources are available on a perpetual basis. These include solar, wind, water (hydropower, tidal and waves), biofuels and geothermal energy. Some energy sources can be replenished over relatively short periods of time. These include wood and other biomass. All are considered renewable.<br>• Secondary sources of energy, such as electricity, are used to store, move, and deliver energy easily in usable form. Hydrogen is also a secondary source of energy, also called an energy carrier.<br>• Thermal and radiant energy can be converted into mechanical energy, chemical energy, and electrical energy and back again. | In order to meet this standard, it is expected that students will<br>• compare and contrast potential and kinetic energy through common examples found in the natural environment.<br>• analyze and describe the transformations of energy involved with the formation and burning of coal and other fossil fuels.<br>• compare and contrast renewable (solar, wind, water [hydropower, tidal and waves], biofuels, geothermal, and biomass) and nonrenewable energy sources (coal, petroleum, natural gas, nuclear power).<br>• explain that hydrogen is not an energy source, but a means of storing and transporting energy.<br>• design an application of the use of solar and wind energy.<br>• chart and analyze the energy a person uses during a 24-hour period and determine the sources.<br>• compare and contrast energy sources in terms of their origins, how they are utilized, and their availability.<br>• analyze the advantages and disadvantages of using various energy sources and their impact on climate and the environment.<br>• analyze and describe how the United States' energy use has changed over time.<br>• analyze and describe sources of energy used in Virginia related to energy use nationally and globally. |

| | |
|---|---|
| 6.2 | The student will investigate and understand basic sources of energy, their origins, transformations, and uses. Key concepts include<br>a) potential and kinetic energy;<br>b) the role of the sun in the formation of most energy sources on Earth;<br>c) nonrenewable energy sources;<br>d) renewable energy sources; and<br>e) energy transformations. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| | • predict the impact of unanticipated energy shortages.<br>• comprehend and apply basic terminology related to energy sources and transformations.<br>• create and interpret a model or diagram of an energy transformation.<br>• design an investigation that demonstrates how light energy (radiant energy) can be transformed into other forms of energy (mechanical, chemical and electrical). |

| | |
|---|---|
| 6.3 | The student will investigate and understand the role of solar energy in driving most natural processes within the atmosphere, the hydrosphere, and on Earth's surface. Key concepts include<br>a) Earth's energy budget;<br>b) the role of radiation and convection in the distribution of energy;<br>c) the motion of the atmosphere and the oceans;<br>d) cloud formation; and<br>e) the role of thermal energy in weather-related phenomena including thunderstorms and hurricanes. |

## Overview

The key concepts defined in this standard are intended to expand student understanding of the effects of solar radiation entering Earth's atmosphere on weather and ocean current patterns. The distribution of energy through convection and radiation are explored as students study cloud formation and movement patterns of the atmosphere and the world's oceans. This standard is closely related to standards 6.2 and 6.6 and builds on the weather concepts developed in standard 4.6 and concepts of visible light in standard 5.3. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.

6.3 The student will investigate and understand the role of solar energy in driving most natural processes within the atmosphere, the hydrosphere, and on Earth's surface. Key concepts include

a) Earth's energy budget;
b) the role of radiation and convection in the distribution of energy;
c) the motion of the atmosphere and the oceans;
d) cloud formation; and
e) the role of thermal energy in weather-related phenomena including thunderstorms and hurricanes.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Earth receives only a very small portion of the sun's energy, yet this energy is responsible for powering the motion of the atmosphere, the oceans, and many processes at Earth's surface.<br>• Solar radiation is made up of different types of radiation (including infrared, visible light, and ultraviolet).<br>• Incoming solar radiation is in close balance with the energy that leaves the atmosphere; otherwise Earth would heat up or cool down. Excess carbon dioxide and other gases may disrupt this balance, creating a greenhouse effect.<br>• About one-third of the sun's incoming energy is reflected back out to space. About one-half of the energy striking Earth is absorbed by Earth's surface.<br>• Earth's surface is heated unequally.<br>• When air or water is heated, the molecules move faster and farther apart, reducing their density and causing them to rise. Cooler air or water molecules move more slowly and are denser than warm air or water. Warm air or water rising coupled with cooler air or water descending forms a cyclic rising/falling pattern called convection.<br>• Radiation and convection from Earth's surface transfer thermal energy. This energy powers the global circulation of the atmosphere and the oceans on our planet.<br>• As bodies of water (oceans, lakes, rivers, etc.) absorb thermal energy, | In order to meet this standard, it is expected that students will<br>• comprehend and apply basic terminology related to solar energy, including wavelength; ultraviolet, visible, and infrared radiation; and reflection and absorption.<br>• analyze and interpret a chart or diagram showing Earth's energy budget.<br>• analyze, model, and explain the greenhouse effect in terms of the energy entering and leaving the atmosphere.<br>• design an investigation to determine the effect of sunlight on the heating of a surface.<br>• analyze and explain how convection currents occur and how they distribute thermal energy in the atmosphere and oceans.<br>• analyze the role of heating and cooling in the formation of clouds.<br>• order the sequence of events that takes place in the formation of a cloud.<br>• describe the relationship between thermal energy and the formation of hurricanes and thunderstorms. |

| | |
|---|---|
| 6.3 | The student will investigate and understand the role of solar energy in driving most natural processes within the atmosphere, the hydrosphere, and on Earth's surface. Key concepts include<br>a) Earth's energy budget;<br>b) the role of radiation and convection in the distribution of energy;<br>c) the motion of the atmosphere and the oceans;<br>d) cloud formation; and<br>e) the role of thermal energy in weather-related phenomena including thunderstorms and hurricanes. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| the water evaporates causing the air to be warm and moist. Warm, moist air is less dense than cold, dry air, so it rises relative to colder, drier air. As warm, moist air rises, it gives off some thermal energy as the moisture condenses, forming clouds. Clouds are not gaseous water vapor; rather they are minute, condensed water particles.<br>• Some thunderstorms are formed where the land is strongly heated. Hurricanes form over warm, tropical water and are fed by the energy of that water. | |

Grade Six
Science Strand

## Matter

This strand focuses on the description, physical properties, and basic structure of matter. The major topics developed in this strand include concepts related to the basic description of objects, phases of matter (solids, liquids, and gases – especially water), phase changes, mass and volume, and the structure of classification of matter. This strand includes science standards K.4, K.5, 1.3, 2.3, 3.3, 5.4, 6.4, 6.5, and 6.6.

| | |
|---|---|
| 6.4 | The student will investigate and understand that all matter is made up of atoms. Key concepts include<br>a) atoms consist of particles, including electrons, protons, and neutrons;<br>b) atoms of a particular element are alike but are different from atoms of other elements;<br>c) elements may be represented by chemical symbols;<br>d) two or more atoms interact to form new substances, which are held together by electrical forces (bonds);<br>e) compounds may be represented by chemical formulas;<br>f) chemical equations can be used to model chemical changes; and<br>g) a limited number of elements comprise the largest portion of the solid Earth, living matter, the oceans, and the atmosphere. |

## Overview

Standard 6.4 focuses on an understanding of the basic structure of the atom, including electrons, protons, and neutrons. The concepts defined in standard 6.4 build on students' basic understanding of the concept of matter as introduced in science standards 3.3 and 5.4. Knowledge of basic chemistry concepts is fundamental to understanding the physical sciences, life processes, and Earth and environmental science ideas. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (6.1) in the context of the key concepts presented in this standard.

| | |
|---|---|
| 6.4 | The student will investigate and understand that all matter is made up of atoms. Key concepts include<br>a) atoms consist of particles, including electrons, protons, and neutrons;<br>b) atoms of a particular element are alike but are different from atoms of other elements;<br>c) elements may be represented by chemical symbols;<br>d) two or more atoms interact to form new substances, which are held together by electrical forces (bonds);<br>e) compounds may be represented by chemical formulas;<br>f) chemical equations can be used to model chemical changes; and<br>g) a limited number of elements comprise the largest portion of the solid Earth, living matter, the oceans, and the atmosphere. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• The basic structural components of a typical atom are electrons, protons, and neutrons. Protons and neutrons comprise the nucleus of an atom.<br>• An element is a form of matter made up of one type of atom. The atoms of an element are basically alike, though the number of neutrons may vary.<br>• The atoms of one element differ from those of another element in the number of protons.<br>• Elements can be represented by chemical symbols.<br>• Two or more atoms of different elements may combine to form a compound.<br>• Compounds can be represented by chemical formulas. Each different element in the compound is represented by its unique symbol. The number of each type of element in the compound (other than 1) is represented by a small number (the subscript) to the right of the element symbol.<br>• Chemical equations can be used to model chemical changes, illustrating how elements become rearranged in a chemical reaction.<br>• A limited number of elements, including silicon, aluminum, iron, sodium, calcium, potassium, magnesium, hydrogen, oxygen, nitrogen, and carbon, form the largest portion of Earth's crust, living matter, the | In order to meet this standard, it is expected that students will<br>• create and interpret a simplified modern model of the structure of an atom.<br>• compare and contrast the atomic structure of two different elements.<br>• explain that elements are represented by symbols.<br>• identify the name and number of each element present in a simple molecule or compound, such as $O_2$, $H_2O$, $CO_2$, or $CaCO_3$.<br>• model a simple chemical change with an equation and account for all atoms. Distinguish the types of elements and number of each element in the chemical equation. (Balancing equations will be further developed in Physical Science.)<br>• name some of the predominant elements found in the atmosphere, the oceans, living matter, and Earth's crust. |

| | |
|---|---|
| 6.4 | The student will investigate and understand that all matter is made up of atoms. Key concepts include<br>a) atoms consist of particles, including electrons, protons, and neutrons;<br>b) atoms of a particular element are alike but are different from atoms of other elements;<br>c) elements may be represented by chemical symbols;<br>d) two or more atoms interact to form new substances, which are held together by electrical forces (bonds);<br>e) compounds may be represented by chemical formulas;<br>f) chemical equations can be used to model chemical changes; and<br>g) a limited number of elements comprise the largest portion of the solid Earth, living matter, the oceans, and the atmosphere. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| oceans, and the atmosphere. | |

| | |
|---|---|
| 6.5 | The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include<br>g) water as the universal solvent;<br>h) the properties of water in all three phases;<br>i) the action of water in physical and chemical weathering;<br>j) the ability of large bodies of water to store thermal energy and moderate climate;<br>k) the importance of water for agriculture, power generation, and public health; and<br>l) the importance of protecting and maintaining water resources. |

## Overview

Standard 6.5 is intended to develop student understanding of the unique properties of water and the importance of protecting and managing water resources. Understanding the structure, properties, and behavior of the water molecule is fundamental to understanding more complex environmental systems. Concepts like solubility, surface tension, cohesion, adhesion, density, condensation, and evaporation can be investigated to appreciate why the properties of water are critical to life processes and living things. This standard also introduces the concept of the ability of large bodies of water to moderate the climate on land. The connections between water resources and agriculture, power generation, and public health are also investigated. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.

| | |
|---|---|
| 6.5 | The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include<br>a) water as the universal solvent;<br>b) the properties of water in all three phases;<br>c) the action of water in physical and chemical weathering;<br>d) the ability of large bodies of water to store thermal energy and moderate climate;<br>e) the importance of water for agriculture, power generation, and public health; and<br>f) the importance of protecting and maintaining water resources. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Among water's unique properties is that one side of each water molecule is slightly negative and the other is slightly positive. Individual water molecules, therefore, attract other water molecules like little magnets as the slightly positive portion of a water molecule is attracted to the slightly negative portion of an adjacent water molecule. In this way, water molecules "stick together."<br>• Due to water's polar nature, a large number of substances will "dissolve" in water. For this reason, water is often called the universal solvent.<br>• Water is the only compound that commonly exists in all three states (solid, liquid, gas) on Earth. The unique properties of water are a major factor in the ability of our planet to sustain life.<br>• Additional properties of water are its high surface tension and the large range of temperature (0–100 degrees Celsius) in which it can be found in the liquid state, as well as the fact that, unlike other substances, solid water is less dense than liquid water.<br>• Water is able to absorb thermal energy without showing relatively large changes in temperature. Large bodies of water act to moderate the climate of surrounding areas by absorbing thermal energy in summer and slowly releasing that energy in the winter. For this reason, the climate near large bodies of water is slightly milder than areas without large bodies of water. | In order to meet this standard, it is expected that students will<br>• comprehend and apply key terminology related to water and its properties and uses.<br>• model and explain the shape and composition of a water molecule.<br>• design an investigation to demonstrate the ability of water to dissolve materials.<br>• comprehend the adhesive and cohesive properties of water.<br>• compare the effects of adding thermal energy to the states of water.<br>• explain why ice is less dense than liquid water.<br>• relate the three states of water to the water cycle.<br>• design an investigation to model the action of freezing water on rock material.<br>• design an investigation to determine the presence of water in plant material (e.g., a fruit).<br>• infer how the unique properties of water are key to the life processes of organisms.<br>• design an investigation to model the action of acidified water on building materials such as concrete, limestone, or marble.<br>• chart, record, and describe evidence of chemical weathering in the |

| | |
|---|---|
| 6.5 | The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include<br>a) water as the universal solvent;<br>b) the properties of water in all three phases;<br>c) the action of water in physical and chemical weathering;<br>d) the ability of large bodies of water to store thermal energy and moderate climate;<br>e) the importance of water for agriculture, power generation, and public health; and<br>f) the importance of protecting and maintaining water resources. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| • Water (rain, ice, snow) has shaped our environment by physically and chemically weathering rock and soil and transporting sediments. Freezing water can break rock without any change in the minerals that form the rock (physical weathering). This usually produces small particles and sand. Water with dissolved gases and other chemicals causes the minerals in rocks to be changed, leading to the deterioration of the rock (chemical weathering).<br>• Most of Earth's water is salt water in the oceans (97 percent). Nonfrozen, fresh water makes up less than 1 percent of the water on Earth.<br>• Water is essential for agriculture. Crops watered by reliable irrigation systems are more productive and harvests more dependable.<br>• Water is an important resource used in power generation. Hydroelectric power plants make use of the kinetic energy of water as it flows through turbines. Water is also heated in power plants and turned to steam. The steam is used to turn turbines, which generate electricity.<br>• In the past, streams and rivers were often used to dispose of human waste, and open sewers were common. During the mid-1800s, public health officials recognized the connection between disease outbreaks and contamination of public wells and drinking water. Advances in water treatment and sanitary sewers have helped eliminate diseases associated with human waste.<br>• Due to water's importance in power generation, agriculture, and human health, it is important to conserve water resources. | local environment.<br>• analyze and explain the difference in average winter temperatures among areas in central and western Virginia and cities and counties along the Chesapeake Bay and Atlantic coast.<br>• explain the role of water in power generation.<br>• describe the importance of careful management of water resources. |

| | |
|---|---|
| 6.5 | The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include<br>a) water as the universal solvent;<br>b) the properties of water in all three phases;<br>c) the action of water in physical and chemical weathering;<br>d) the ability of large bodies of water to store thermal energy and moderate climate;<br>e) the importance of water for agriculture, power generation, and public health; and<br>f) the importance of protecting and maintaining water resources. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| | |

| | |
|---|---|
| 6.6 | The student will investigate and understand the properties of air and the structure and dynamics of Earth's atmosphere. Key concepts include<br>g) air as a mixture of gaseous elements and compounds;<br>h) pressure, temperature, and humidity;<br>i) atmospheric changes with altitude;<br>j) natural and human-caused changes to the atmosphere and the importance of protecting and maintaining air quality;<br>k) the relationship of atmospheric measures and weather conditions; and<br>l) basic information from weather maps, including fronts, systems, and basic measurements. |

## Overview

Standard 6.6 is intended to provide students with a basic understanding of the properties of air, the structure of the atmosphere, weather, and air quality. Students need to understand there are both natural and human-caused changes to the atmosphere and that the results of these changes are not yet fully known. A basic understanding of weather and weather prediction builds on the key concepts in standard 4.6. Standard 6.6 also focuses on student understanding of air quality as an important parameter of human and environmental health. It is important to make the obvious connections between this standard and the other sixth-grade standards. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.

6.6 The student will investigate and understand the properties of air and the structure and dynamics of Earth's atmosphere. Key concepts include
a) air as a mixture of gaseous elements and compounds;
b) pressure, temperature, and humidity;
c) atmospheric changes with altitude;
d) natural and human-caused changes to the atmosphere and the importance of protecting and maintaining air quality;
e) the relationship of atmospheric measures and weather conditions; and
f) basic information from weather maps, including fronts, systems, and basic measurements.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Air is a mixture of gaseous elements and compounds. These include nitrogen, oxygen, water, argon and carbon dioxide. Nitrogen makes up the largest proportion of air.<br>• Air exerts pressure. Air pressure decreases as altitude increases.<br>• Moisture in the air is called humidity.<br>• The atmosphere is made up of layers (troposphere, stratosphere, mesosphere, and thermosphere) that have distinct characteristics.<br>• Temperature decreases as altitude increases in the lowest layer of the atmosphere.<br>• Most of the air that makes up the atmosphere is found in the troposphere (the lowest layer). Virtually all weather takes place there.<br>• Forest fires and volcanic eruptions are two natural processes that affect Earth's atmosphere. Many gaseous compounds and particles are released into the atmosphere by human activity. All of the effects of these materials are not yet fully understood.<br>• The amounts of thermal energy and water vapor in the air and the pressure of the air largely determine what the weather conditions are.<br>• Clouds are important indicators of atmospheric conditions. Clouds are found at various levels within the troposphere. Three major types of clouds are cumulus, stratus, and cirrus.<br>• Ozone, a form of oxygen, can form near the surface when exhaust | In order to meet this standard, it is expected that students will<br>• comprehend and apply basic terminology related to air and the atmosphere.<br>• identify the composition and physical characteristics of the atmosphere.<br>• analyze and interpret charts and graphs of the atmosphere in terms of temperature and pressure.<br>• measure and record air temperature, air pressure, and humidity, using appropriate units of measurement and tools.<br>• analyze and explain some of the effects that natural events and human activities may have on weather, atmosphere, and climate.<br>• evaluate their own roles in protecting air quality.<br>• design an investigation to relate temperature, barometric pressure, and humidity to changing weather conditions.<br>• compare and contrast cloud types and relate cloud types to weather conditions.<br>• compare and contrast types of precipitation.<br>• compare and contrast weather-related phenomena, including thunderstorms, tornadoes, hurricanes, and drought.<br>• interpret basic weather maps and make forecasts based on the information presented. |

| 6.6 | The student will investigate and understand the properties of air and the structure and dynamics of Earth's atmosphere. Key concepts include<br>a) air as a mixture of gaseous elements and compounds;<br>b) pressure, temperature, and humidity;<br>c) atmospheric changes with altitude;<br>d) natural and human-caused changes to the atmosphere and the importance of protecting and maintaining air quality;<br>e) the relationship of atmospheric measures and weather conditions; and<br>f) basic information from weather maps, including fronts, systems, and basic measurements. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| pollutants react with sunlight. This pollutant can cause health problems. Naturally occurring ozone is also found in the upper atmosphere and helps to shield Earth from ultraviolet radiation.<br>• Maintaining good air quality is a crucial goal for modern society, and it is everyone's responsibility to work toward it.<br>• Weather maps show much useful information about descriptive air measurements, observations, and boundaries between air masses (fronts). The curved lines showing areas of equal air pressure and temperature are key features of weather maps. Weather maps are important for understanding and predicting the weather. | • map the movement of cold and warm fronts and interpret their effects on observable weather conditions. |

Grade Six
Science Strand

## Living Systems

The strand begins in second grade and builds from basic to more complex understandings of a system, both at the ecosystem level and at the level of the cell. The concept of kingdoms of organisms and a general classification of organisms are also presented. The other major topics developed in the strand include the types of relationships among organisms in a food chain, different types of environments and the organisms they support, and the relationship between organisms and their nonliving environment. This strand includes science standards 2.5, 3.5, 3.6, 4.5, 5.5, and 6.7.

| | |
|---|---|
| 6.7 | The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include<br>g) the health of ecosystems and the abiotic factors of a watershed;<br>h) the location and structure of Virginia's regional watershed systems;<br>i) divides, tributaries, river systems, and river and stream processes;<br>j) wetlands;<br>k) estuaries;<br>l) major conservation, health, and safety issues associated with watersheds; and<br>m) water monitoring and analysis using field equipment including hand-held technology. |

## Overview

Standard 6.7 is intended to provide students with a basic understanding of how natural processes and human interactions impact watershed systems. This includes an understanding of the physical geography of Virginia's portions of the three major watershed systems (the Chesapeake Bay, the North Carolina sounds, and the Gulf of Mexico) and the various features associated with moving water (surface and groundwater). Wetlands have become an important focus of scientists as we learn their role in flood and erosion control as well as their importance as habitat for many species of living things. Students are introduced to major safety and conservation issues associated with watersheds and become familiar with the testing parameters and tools used in the field. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.

6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include

a) the health of ecosystems and the abiotic factors of a watershed;
b) the location and structure of Virginia's regional watershed systems;
c) divides, tributaries, river systems, and river and stream processes;
d) wetlands;
e) estuaries;
f) major conservation, health, and safety issues associated with watersheds; and
g) water monitoring and analysis using field equipment including hand-held technology.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br><br>• An ecosystem is made up of the biotic (living) community and the abiotic (nonliving) factors that affect it. The health of an ecosystem is directly related to water quality.<br><br>• Abiotic factors determine ecosystem type and its distribution of plants and animals as well as the usage of land by people. Abiotic factors include water supply, topography, landforms, geology, soils, sunlight, and air quality/$O_2$ availability.<br><br>• Human activities can alter abiotic components and thus accelerate or decelerate natural processes. For example, people can affect the rate of natural erosion. Plowing cropland can cause greater erosion, while planting trees can prevent it. Flood protection/wetland loss is another example.<br><br>• A watershed is the land that water flows across or through on its way to a stream, lake, wetland, or other body of water. Areas of higher elevations, such as ridgelines and divides, separate watersheds.<br><br>• The three major regional watershed systems in Virginia lead to the Chesapeake Bay, the North Carolina sounds, or the Gulf of Mexico.<br><br>• River systems are made up of tributaries of smaller streams that join along their courses. Rivers and streams generally have wide, flat, border areas, called flood plains, onto which water spills out at times of high flow. | In order to meet this standard, it is expected that students will<br><br>• comprehend and apply basic terminology related to watersheds.<br><br>• use topographic maps to determine the location and size of Virginia's regional watershed systems.<br><br>• locate their own local watershed and the rivers and streams associated with it.<br><br>• design an investigation to model the effects of stream flow on various slopes.<br><br>• analyze and explain the functioning of wetlands and appraise the value of wetlands to humans.<br><br>• explain what an estuary is and why it is important to people.<br><br>• propose ways to maintain water quality within a watershed.<br><br>• explain the factors that affect water quality in a watershed and how those factors can affect an ecosystem.<br><br>• forecast potential water-related issues that may become important in the future.<br><br>• locate and critique a media article or editorial (print or electronic) concerning water use or water quality. Analyze and evaluate the science concepts involved. |

6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include

a) the health of ecosystems and the abiotic factors of a watershed;
b) the location and structure of Virginia's regional watershed systems;
c) divides, tributaries, river systems, and river and stream processes;
d) wetlands;
e) estuaries;
f) major conservation, health, and safety issues associated with watersheds; and
g) water monitoring and analysis using field equipment including hand-held technology.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| • Rivers and streams carry and deposit sediment. As water flow decreases in speed, the size of the sediment it carries decreases.<br>• Wetlands form the transition zone between dry land and bodies of water such as rivers, lakes, or bays. Both tidal and nontidal wetlands perform important water quality functions, including regulating runoff by storing flood waters; reducing erosion by slowing down run-off; maintaining water quality by filtering sediments, trapping nutrients, and breaking down pollutants; and recharging groundwater. They also provide food and shelter for wildlife and fish and nesting and resting areas for migratory birds.<br>• Estuaries perform important functions, such as providing habitat for many organisms and serving as nurseries for their young.<br>• The Chesapeake Bay is an estuary where fresh and salt water meet and are mixed by tides. It is the largest estuary in the contiguous United States and one of the most productive.<br>• Water quality monitoring is the collection of water samples to analyze chemical and/or biological parameters. Simple parameters include pH, temperature, salinity, dissolved oxygen, turbidity, and the presence of macroinvertebrate organisms. | • argue for and against commercially developing a parcel of land containing a large wetland area. Design and defend a land-use model that minimizes negative impact.<br>• measure, record, and analyze a variety of water quality indicators and describe what they mean to the health of an ecosystem. |

Grade Six
Science Strand

## Interrelationships in Earth/Space Systems

The strand focuses on student understanding of how Earth systems are connected and how Earth interacts with other members of the solar system. The topics developed include shadows; relationships between the sun and Earth; weather types, patterns, and instruments; properties of soil; characteristics of the ocean environment; and organization of the solar system. This strand includes science standards K.7, 1.6, 2.6, 3.7, 4.6, 4.7, 4.8, 5.6, and 6.8.

6.8 The student will investigate and understand the organization of the solar system and the interactions among the various bodies that comprise it. Key concepts include

j) the sun, moon, Earth, other planets and their moons, dwarf planets, meteors, asteroids, and comets;
k) relative size of and distance between planets;
l) the role of gravity;
m) revolution and rotation;
n) the mechanics of day and night and the phases of the moon;
o) the unique properties of Earth as a planet;
p) the relationship of Earth's tilt and the seasons;
q) the cause of tides; and
r) the history and technology of space exploration.

## Overview

Standard 6.8 is intended to provide students with a basic understanding of the solar system and the relationships among bodies within the solar system. This standard develops an understanding of Earth as part of the solar system and builds significantly on standards 3.8, 4.7, and 4.8. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.

| | |
|---|---|
| 6.8 | The student will investigate and understand the organization of the solar system and the interactions among the various bodies that comprise it. Key concepts include<br>a) the sun, moon, Earth, other planets and their moons, dwarf planets, meteors, asteroids, and comets;<br>b) relative size of and distance between planets;<br>c) the role of gravity;<br>d) revolution and rotation;<br>e) the mechanics of day and night and the phases of the moon;<br>f) the unique properties of Earth as a planet;<br>g) the relationship of Earth's tilt and the seasons;<br>h) the cause of tides; and<br>i) the history and technology of space exploration. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• The solar system consists of the sun, moon, Earth, other planets and their moons, meteors, asteroids, and comets. Each body has its own characteristics and features.<br>• The distance between planets and sizes of the planets vary greatly. The outer, "gas" planets are very large, and the four inner planets are comparatively small and rocky.<br>• Gravity is a force that keeps the planets in motion around the sun. Gravity acts everywhere in the universe.<br>• Planets revolve around the sun, and moons revolve around planets. A planet rotates upon an axis.<br>• A dwarf planet revolves around the sun, and can maintain a nearly round shape as planets do, but it cannot move other objects away from its orbital neighborhood.<br>• As Earth rotates, different sides of Earth face toward or away from the sun, thus causing day and night, respectively.<br>• The phases of the moon are caused by its position relative to Earth and the sun.<br>• Earth is a rocky planet, extensively covered with large oceans of liquid | In order to meet this standard, it is expected that students will<br>• describe the planets and their relative positions from the sun.<br>• compare the characteristics of Pluto to the planets and explain its designation as a dwarf planet.<br>• design and interpret a scale model of the solar system. (A scale model may be a physical representation of an object or concept. It can also be a mathematical representation that uses factors such as ratios, proportions, and percentages.)<br>• explain the role of gravity in the solar system.<br>• compare and contrast revolution and rotation and apply these terms to the relative movements of planets and their moons.<br>• model and describe how day and night and the phases of the moon occur.<br>• model and describe how Earth's axial tilt and its annual orbit around the sun cause the seasons.<br>• describe the unique characteristics of planet Earth.<br>• discuss the relationship between the gravitational pull of the moon and the cycle of tides. |

| | |
|---|---|
| 6.8 | The student will investigate and understand the organization of the solar system and the interactions among the various bodies that comprise it. Key concepts include<br>a) the sun, moon, Earth, other planets and their moons, dwarf planets, meteors, asteroids, and comets;<br>b) relative size of and distance between planets;<br>c) the role of gravity;<br>d) revolution and rotation;<br>e) the mechanics of day and night and the phases of the moon;<br>f) the unique properties of Earth as a planet;<br>g) the relationship of Earth's tilt and the seasons;<br>h) the cause of tides; and<br>i) the history and technology of space exploration. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| water and having frozen ice caps in its polar regions. Earth has a protective atmosphere consisting predominantly of nitrogen and oxygen and has a magnetic field. The atmosphere and the magnetic field help shield Earth's surface from harmful solar radiation. Scientific evidence indicates that Earth is about 4.5 billion years old.<br>• Seasons are caused by a combination of the tilt of Earth on its axis, the curvature of Earth's surface and, thus, the angle at which sunlight strikes the surface of Earth during its annual revolution around the sun.<br>• Tides are the result of the gravitational pull of the moon and sun on the surface waters of Earth.<br>• The ideas of Ptolemy, Aristotle, Copernicus, and Galileo contributed to the development of our understanding of the solar system.<br>• With the development of new technology over the last half-century, our knowledge of the solar system has increased substantially. | • compare and contrast the ideas of Ptolemy, Aristotle, Copernicus, and Galileo related to the solar system.<br>• create and interpret a timeline highlighting the advancements in solar system exploration over the past half century. This should include information on the first modern rockets, artificial satellites, orbital missions, missions to the moon, Mars robotic explorers, and exploration of the outer planets. |

Grade Six
Science Strand

## Earth Resources

The strand focuses on student understanding of the role of resources in the natural world and how people can utilize those resources in a sustainable way. An important idea represented in this strand is the importance of managing resources. This begins with basic ideas of conservation and proceeds to more abstract consideration of costs and benefits. The topics developed include conservation of materials, soil and plants as resources, energy use, water, Virginia's resources, and how public policy impacts the environment. This strand includes science standards K.11, 1.8, 2.8, 3.10, 3.11, 4.9, and 6.9.

| | |
|---|---|
| 6.9 | The student will investigate and understand public policy decisions relating to the environment. Key concepts include<br>a) management of renewable resources;<br>b) management of nonrenewable resources;<br>c) the mitigation of land-use and environmental hazards through preventive measures; and<br>d) cost/benefit tradeoffs in conservation policies. |

## Overview

Standard 6.9 is intended to develop student understanding of the importance of Earth's natural resources, the need to manage them, how they are managed, and the analysis of costs and benefits in making decisions about those resources. It applies and builds on the concepts described in several lower grades, especially science standard 4.9. Knowledge gained from this standard will be important to understanding numerous concepts in Life Science and Earth Science. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.

| | |
|---|---|
| 6.9 | The student will investigate and understand public policy decisions relating to the environment. Key concepts include<br>a) management of renewable resources;<br>b) management of nonrenewable resources;<br>c) the mitigation of land-use and environmental hazards through preventive measures; and<br>d) cost/benefit tradeoffs in conservation policies. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• People, as well as other living organisms, are dependent upon the availability of clean water and air and a healthy environment.<br>• Local, state, and federal governments have significant roles in managing and protecting air, water, plant, and wildlife resources.<br>• Modern industrial society is dependent upon energy. Fossil fuels are the major sources of energy in developed and industrialized nations and should be managed to minimize adverse impacts.<br>• Many renewable and nonrenewable resources are managed by the private sector (private individuals and corporations).<br>• Renewable resources should be managed so that they produce continuously. Sustainable development makes decisions about long-term use of the land and natural resources for maximum community benefit for the longest time and with the least environmental damage.<br>• Regulations, incentives, and voluntary efforts help conserve resources and protect environmental quality.<br>• Conservation of resources and environmental protection begin with individual acts of stewardship.<br>• Use of renewable (water, air, soil, plant life, animal life) and nonrenewable resources (coal, oil, natural gas, nuclear power, and mineral resources) must be considered in terms of their cost/benefit tradeoffs.<br>• Preventive measures, such as pollution prevention or thoughtfully planned and enforced land-use restrictions, can reduce the impact of potential problems in the future.<br>• Pollution prevention and waste management are less costly than | In order to meet this standard, it is expected that students will<br>• differentiate between renewable and nonrenewable resources.<br>• describe the role of local and state conservation professionals in managing natural resources. These include wildlife protection; forestry and waste management; and air, water, and soil conservation.<br>• analyze resource-use options in everyday activities and determine how personal choices have costs and benefits related to the generation of waste.<br>• analyze how renewable and nonrenewable resources are used and managed within the home, school, and community.<br>• analyze reports, media articles, and other narrative materials related to waste management and resource use to determine various perspectives concerning the costs/benefits in real-life situations.<br>• evaluate the impact of resource use, waste management, and pollution prevention in the school and home environment. |

| | |
|---|---|
| 6.9 | The student will investigate and understand public policy decisions relating to the environment. Key concepts include<br>a) management of renewable resources;<br>b) management of nonrenewable resources;<br>c) the mitigation of land-use and environmental hazards through preventive measures; and<br>d) cost/benefit tradeoffs in conservation policies. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| cleanup. | |

## Science Standards of Learning

# Curriculum Framework 2010

# Life Science

# Standard LS.1

| | |
|---|---|
| LS.1 | The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which<br>a) data are organized into tables showing repeated trials and means;<br>b) a classification system is developed based on multiple attributes;<br>c) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, and probeware are used to gather data;<br>d) models and simulations are constructed and used to illustrate and explain phenomena;<br>e) sources of experimental error are identified;<br>f) dependent variables, independent variables, and constants are identified;<br>g) variables are controlled to test hypotheses and trials are repeated;<br>h) data are organized, communicated through graphical representation, interpreted, and used to make predictions;<br>i) patterns are identified in data and are interpreted and evaluated; and<br>j) current applications are used to reinforce life science concepts. |

## Overview

The skills described in standard LS.1 are intended to define the "investigate" component of all of the other Life Science standards (LS.2–LS.14). The intent of standard LS.1 is that students will continue to develop a range of inquiry skills and achieve proficiency with those skills in the context of the concepts developed in the Life Science course. This does not preclude explicit instruction on a particular inquiry skill or skills, but standard LS.1 does not require a discrete unit on scientific investigation. It is also intended that by developing these skills, students will achieve greater understanding of scientific inquiry and the nature of science, as well as more fully grasp the content-related concepts. Models, simulations and current applications should be used throughout the course in order to learn and reinforce science concepts.

Across the grade levels, kindergarten through high school, the skills in the first standards form a nearly continuous sequence. It is very important that the Life Science teacher be familiar with the skills in the sequence leading up to standard LS.1 (6.1, 5.1, 4.1).

## Standard LS.1

| | |
|---|---|
| LS.1 | The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which<br>a) data are organized into tables showing repeated trials and means;<br>b) a classification system is developed based on multiple attributes;<br>c) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, and probeware are used to gather data;<br>d) models and simulations are constructed and used to illustrate and explain phenomena;<br>e) sources of experimental error are identified;<br>f) dependent variables, independent variables, and constants are identified;<br>g) variables are controlled to test hypotheses and trials are repeated;<br>h) data are organized, communicated through graphical representation, interpreted, and used to make predictions;<br>i) patterns are identified in data and are interpreted and evaluated; and<br>j) current applications are used to reinforce life science concepts. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world. The nature of science includes the following concepts<br>a) the natural world is understandable;<br>b) science is based on evidence - both observational and experimental;<br>c) science is a blend of logic and innovation;<br>d) scientific ideas are durable yet subject to change as new data are collected;<br>e) science is a complex social endeavor; and<br>f) scientists try to remain objective and engage in peer review to help avoid bias.<br>• Expected results are reflected in the organization of a data table, which includes areas to record the number of repeated trials, levels of the independent variable, measured results for the dependent variable, and analysis of the results by calculation of mathematical means. | In order to meet this standard, it is expected that students will<br>• make connections between the components of the nature of science and their investigations and the greater body of scientific knowledge and research.<br>• design a data table to organize all components of an investigation in a meaningful way.<br>• develop and use a classification system that uses numerous attributes to organize information and discern patterns.<br>• select and use appropriate tools and techniques for collecting qualitative and quantitative data in classroom and field investigations.<br>• create and use mental and physical models (including simulations) as ways to visualize explanations of ideas and phenomena.<br>• identify potential sources of error in the design of an experiment.<br>• evaluate the design of an experiment and the events that occur during an investigation to determine which factors may affect the results of the experiment. This requires students to examine the experimental procedure and decide where or if they have made mistakes. |

# Standard LS.1

| | |
|---|---|
| LS.1 | The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which<br>a) data are organized into tables showing repeated trials and means;<br>b) a classification system is developed based on multiple attributes;<br>c) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, and probeware are used to gather data;<br>d) models and simulations are constructed and used to illustrate and explain phenomena;<br>e) sources of experimental error are identified;<br>f) dependent variables, independent variables, and constants are identified;<br>g) variables are controlled to test hypotheses and trials are repeated;<br>h) data are organized, communicated through graphical representation, interpreted, and used to make predictions;<br>i) patterns are identified in data and are interpreted and evaluated; and<br>j) current applications are used to reinforce life science concepts. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| • Scientists create and apply classification systems to organize information and discern patterns.<br>• Appropriate tools and techniques are used to gather data during scientific investigations. Measurements are collected using the International System of Units (metric units) of measurement.<br>• Mental and physical models, including computer and other simulations, can be helpful in explaining events or sequences of events that occur. They can be used as part of scientific explanations to support data or represent phenomena, especially those that are not easily seen directly or must be inferred from data.<br>• Potential sources of error in the experimental design must be identified.<br>• To communicate the plan of an experiment accurately, the independent variable, dependent variable, and constants must be explicitly defined.<br>• To establish that the events of an experiment are the result of manipulating the independent variable, the experiment must be controlled by observing the effects without the application of the independent variable. The results can be compared with this standard or control. Not all experiments have a control. | • identify what is deliberately changed in the experiment and what is to be measured as the dependent variable.<br>• analyze the variables in an experiment and decide which ones must be held constant (not allowed to change) in order for the investigation to represent a fair test. This requires students to comprehend what “variables” are and to apply that idea in new situations related to the *Life Science Standards of Learning* concepts.<br>• determine the specific component of an experiment to be changed as an independent variable and control the experiment by conducting trials for the experiment in which the independent variable is not applied. This requires the student to set up a standard to which the experimental results can be compared. The student must use the results of the controlled trials to determine whether the hypothesized results were indeed due to the independent variable.<br>• construct appropriate graphs, using data sets from investigations. This requires the student to recognize that a line graph is most appropriate for reporting continuous or real-time data. This also requires a student to comprehend that points along the line that are not actual data points can be used to make predictions. Students should be able to interpret and analyze these graphs.<br>• distinguish between observational and experimental investigations. |

## Standard LS.1

| | |
|---|---|
| LS.1 | The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which<br>a) data are organized into tables showing repeated trials and means;<br>b) a classification system is developed based on multiple attributes;<br>c) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, and probeware are used to gather data;<br>d) models and simulations are constructed and used to illustrate and explain phenomena;<br>e) sources of experimental error are identified;<br>f) dependent variables, independent variables, and constants are identified;<br>g) variables are controlled to test hypotheses and trials are repeated;<br>h) data are organized, communicated through graphical representation, interpreted, and used to make predictions;<br>i) patterns are identified in data and are interpreted and evaluated; and<br>j) current applications are used to reinforce life science concepts. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| • Multiple trials of an experiment must be conducted to verify the results.<br>• Analysis of observed results of systematic investigations includes construction and interpretation of graphs. Such interpretation can be used to make predictions about the behavior of the dependent variable in other situations and to explore potential sources of error in the experiment. This analysis can be used to support conclusions about the results of the investigation.<br>• Investigations can be classified as observational (descriptive) studies (intended to generate hypotheses), or experimental studies (intended to test hypotheses).<br>• Science concepts are applied through observations and connections with everyday life and technology. | • develop conclusions based on a data set and verify whether the data set truly supports the conclusion. This requires students to cite references to the data that specifically support their conclusions. |

## Standard LS.2

| | |
|---|---|
| LS.2 | The student will investigate and understand that all living things are composed of cells. Key concepts include<br>e) cell structure and organelles;<br>f) similarities and differences between plant and animal cells;<br>g) development of cell theory; and<br>h) cell division. |
| | **Overview**<br>This standard builds on the general concept in science standard 5.5 that states that living things are made of cells. The emphasis here is on the concept that cells are the unit of structure and function of living things and on the concept of subcellular components, or organelles, each with a particular structure and function. The historical contributions of many scientists to the establishment of the cell theory are also important for students to understand. This standard also introduces students to the concept of cell division. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard. |

# Standard LS.2

| | |
|---|---|
| LS.2 | The student will investigate and understand that all living things are composed of cells. Key concepts include<br>a) cell structure and organelles;<br>b) similarities and differences between plant and animal cells;<br>c) development of cell theory; and<br>d) cell division. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• The structure of a cell organelle is suited to the function carried out by that organelle. Division of labor within a cell is essential to the overall successful function of the cell.<br>• Similarities and differences in plants and animals are evident at the cellular level. Plant and animal cells contain some of the same organelles and some that differ.<br>• The original cell theory includes the following components: all living things are composed of cells; cells are the smallest unit (structure) of living things that can perform the processes (functions) necessary for life; and living cells come only from other living cells. (Although it is appropriate for students at this level to understand the three points of the original cell theory, an exploration of the revised cell theory should be reserved for high school Biology.)<br>• The development of the original cell theory can be attributed to the major discoveries of many notable scientists. The development of the cell theory has been dependent upon improvements in the microscope and microscopic techniques throughout the last four centuries.<br>• Continuing advances in microscopes and instrumentation have increased the understanding of cell organelles and their functions. Many of these organelles can now be observed with a microscope (light, electron).<br>• Cells go through a life cycle known as the cell cycle. The phases of the cell cycle are interphase, mitosis, and cytokinesis. (Although it is appropriate for students at this level to learn to recognize the stages of the cell cycle and mitosis, an exploration of the individual stages of | In order to meet this standard, it is expected that students will<br>• distinguish among the following: cell membrane, cytoplasm, nucleus, cell wall, vacuole, mitochondrion, endoplasmic reticulum, and chloroplast.<br>• correlate the structures of cell organelles with their functions.<br>• compare and contrast examples of plant and animal cells, using the light microscope and images obtained from other microscopes.<br>• describe and sequence the major points in the development of the cell theory.<br>• identify the three components of the original cell theory.<br>• sequence the steps in the cell cycle, including the phases of mitosis.<br>• differentiate between the purpose of mitosis and meiosis.<br>• design an investigation from a testable question related to animal and plant cells. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. An example of such a question is: "Do onion cells vary in shape or structure depending on where they are found in the plant?" |

## Standard LS.2

| LS.2 | The student will investigate and understand that all living things are composed of cells. Key concepts include<br>a) cell structure and organelles;<br>b) similarities and differences between plant and animal cells;<br>c) development of cell theory; and<br>d) cell division. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| meiosis may be reserved for high school Biology.)<br>• The purpose of mitosis is to produce new cells for growth and repair that are identical to the parent cell. The purpose of meiosis is to produce reproductive (sex) cells that carry half the genetic material of the parent. | |

## Standard LS.3

| | |
|---|---|
| LS.3 | The student will investigate and understand that living things show patterns of cellular organization. Key concepts include<br>c) cells, tissues, organs, and systems; and<br>d) patterns of cellular organization and their relationship to life processes in living things. |

### Overview

This standard emphasizes the fact that among living organisms, there is a universality of the functions that maintain life. This standard continues to build upon students' knowledge of these functions and introduces students to the process of cellular transport. With the exception of the structures associated with plant reproduction, which are highlighted in 4.4, this is the students' introduction to the specific structures of plants and animals that enable them to perform life functions. Students are introduced to the concepts of unicellular and multicellular organisms and division of labor. This standard is not intended to require student understanding of the details of human body systems. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard.

# Standard LS.3

| | |
|---|---|
| LS.3 | The student will investigate and understand that living things show patterns of cellular organization. Key concepts include<br>a) cells, tissues, organs, and systems; and<br>b) patterns of cellular organization and their relationship to life processes in living things. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Cells that have the same function group together to form tissues. Tissues that have the same function group together to form organs. Organs with similar functions group to work together in an organ system.<br>• Unicellular organisms are made of only one cell. Multicellular organisms are made of many cells.<br>• Multicellular organisms exhibit a hierarchy of cellular organization. They are complex in that there is a division of labor among the levels of this hierarchy for carrying out necessary life processes.<br>• Cells perform numerous functions and processes including cellular respiration, waste breakdown and removal, growth and division, and cellular transport.<br>• Osmosis is the passive transport of water molecules across a cell membrane. Diffusion is the passive transport of substances other than water across a cell membrane. Cell membranes are selectively permeable to various substances. (A discussion of facilitated diffusion, tonicity, and active transport should be reserved for high school Biology.)<br>• Living things carry out life processes including ingestion, digestion and removal of waste, stimulus response, growth and repair, gas exchange, and reproduction.<br>• Numerous factors can strongly influence the life processes of organisms. | In order to meet this standard, it is expected that students will<br>• explain the relationship among cells, tissue, organs, and organ systems.<br>• differentiate between unicellular organisms and multicellular organisms and name common examples of each.<br>• compare and contrast how unicellular and multicellular organisms perform various life functions. This includes the application of knowledge about systems in organisms.<br>• explain the role that each life function serves for an organism: ingestion, digestion and removal of waste, stimulus response, growth and repair, gas exchange, and reproduction.<br>• explain that there is a specific range or continuum of conditions that will meet the needs of organisms.<br>• model how materials move into and out of cells in the processes of osmosis, diffusion, and selective permeability. This includes creating and interpreting three-dimensional models and/or illustrations demonstrating the processes involved. Students should be able to analyze the components of these models and diagrams and communicate their observations and conclusions.<br>• create plausible hypotheses about the effects that changes in available materials might have on particular life processes in plants and in animals.<br>• conduct basic investigations related to understanding cellular organization, with emphasis on observations of cells and tissue. This investigation should focus on the skills developed in LS.1. |

## Standard LS.3

| | |
|---|---|
| LS.3 The student will investigate and understand that living things show patterns of cellular organization. Key concepts include<br>a) cells, tissues, organs, and systems; and<br>b) patterns of cellular organization and their relationship to life processes in living things. | |
| Essential Understandings | Essential Knowledge, Skills, and Processes |
| | |

# Standard LS.4

| LS.4 | The student will investigate and understand how organisms can be classified. Key concepts include<br>a) the distinguishing characteristics of domains of organisms;<br>b) the distinguishing characteristics of kingdoms of organisms;<br>c) the distinguishing characteristics of major animal phyla and plant divisions; and<br>d) the characteristics that define a species. |
|---|---|

## Overview

Classifying and grouping is a key inquiry skill, as described in the K–12 "Investigate and Understand" section of the Introduction to the *Science Standards of Learning.* Classifying is an important skill in the K–6 "Scientific Investigation, Reasoning and Logic" strand. The use of a classification key is introduced in 5.1.

This standard focuses on students practicing classification skills within a hierarchical biological classification system. This is accomplished by analyzing similarities and differences between the structures and functions of organisms. Students should understand that scientists use classification as a tool to organize information about organisms and to gain information about related organisms. This standard does not require a detailed survey of each domain, kingdom or phylum, but rather a general overview of how organisms are grouped and a focus on a few key groups. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard.

## Standard LS.4

| | |
|---|---|
| LS.4 | The student will investigate and understand how organisms can be classified. Key concepts include<br>a) the distinguishing characteristics of domains of organisms;<br>b) the distinguishing characteristics of kingdoms of organisms;<br>c) the distinguishing characteristics of major animal phyla and plant divisions; and<br>d) the characteristics that define a species. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Information about physical features and activities is arranged in a hierarchy of increasing specificity. The levels in the accepted hierarchy include domain, kingdom, phylum, class, order, family, genus and species.<br>• Current classification systems now generally recognize the categorization of organisms into three domains, Archaea, Bacteria and Eukarya.<br>• As living things are constantly being investigated, new attributes (physical and chemical) are revealed that affect how organisms are placed in a standard classification system. This system is the basis for scientific binomial nomenclature.<br>• Any grouping of organisms into domains or kingdoms is based on several factors, including the presence or absence of cellular structures, such as the nucleus, mitochondria, or a cell wall; whether the organisms exist as single cells or are multicellular; and how the organisms get their food. For example, simple, single-celled organisms that are able to survive in extreme environments are believed to be fundamentally different from other organisms and may be classified in their own domain (Archaea). Four different kingdoms of the Eukarya domain of organisms are generally recognized by scientists today (Protista, Fungi, Plants, and Animals).<br>• Some important animal groups (phyla) are the cnidarians, mollusks, annelids, arthropods, echinoderms, and chordates.<br>• Four important plant groups (divisions) are the mosses, ferns, conifers, | In order to meet this standard, it is expected that students will<br>• classify organisms based on a comparison of key physical features and activities.<br>• arrange organisms in a hierarchy according to similarities and differences in features.<br>• categorize examples of organisms as representative of the three domains (Archaea, Bacteria and Eukarya) and recognize that the number of domains is subject to change as new data are collected.<br>• categorize examples of organisms as representative of the kingdoms and recognize that the number of kingdoms is subject to change as new data are collected.<br>• recognize examples of major animal phyla.<br>• recognize examples of major plant divisions.<br>• recognize scientific names as part of a binomial nomenclature. |

## Standard LS.4

| | |
|---|---|
| LS.4 | The student will investigate and understand how organisms can be classified. Key concepts include<br>a) the distinguishing characteristics of domains of organisms;<br>b) the distinguishing characteristics of kingdoms of organisms;<br>c) the distinguishing characteristics of major animal phyla and plant divisions; and<br>d) the characteristics that define a species. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| and flowering plants.<br>• A group of similar-looking organisms that can interbreed under natural conditions and produce offspring that are capable of reproduction defines a species. | |

## Standard LS.5

| | |
|---|---|
| LS.5 | The student will investigate and understand the basic physical and chemical processes of photosynthesis and its importance to plant and animal life. Key concepts include<br>a) energy transfer between sunlight and chlorophyll;<br>b) transformation of water and carbon dioxide into sugar and oxygen; and<br>c) photosynthesis as the foundation of virtually all food webs. |

### Overview

Students learn in 4.4 that photosynthesis is a basic life process of plants requiring chlorophyll and carbon dioxide. This standard pulls these ideas together to demonstrate the complexity and importance of photosynthesis. Energy enters food webs through photosynthesis and is then transferred throughout the food web. It is crucial that students understand the importance of plants (and other photosynthesizing organisms) in this role of providing energy to all other living things. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard.

## Standard LS.5

| LS.5 | The student will investigate and understand the basic physical and chemical processes of photosynthesis and its importance to plant and animal life. Key concepts include<br>a) energy transfer between sunlight and chlorophyll;<br>b) transformation of water and carbon dioxide into sugar and oxygen; and<br>c) photosynthesis as the foundation of virtually all food webs. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Chlorophyll is a chemical in chloroplasts that can absorb or trap light energy.<br>• Photosynthesis is the necessary life process that transforms light energy into chemical energy. It involves a series of chemical reactions in which the light energy is used to change raw materials (carbon dioxide and water) into products (sugar and oxygen). The energy is stored in the chemical bonds of the glucose (sugar) molecules.<br>• Plants perform cellular respiration as well as photosynthesis.<br>• Plants convert the sugars they produce into other raw materials that are used by plants and animals for growth, repair, and energy needs.<br>• Energy is a basic need of all living things. Photosynthesizing organisms obtain their energy from the sun and are often called producers because of their ability to produce glucose (sugar).<br>• Photosynthesizing organisms are the foundation of virtually all food webs. | In order to meet this standard, it is expected that students will<br>• describe the process of photosynthesis in terms of raw materials and products generated.<br>• identify and describe the cellular organelles involved in the process of photosynthesis.<br>• explain how organisms utilize the energy stored from the products of photosynthesis.<br>• compare and contrast the processes of photosynthesis and cellular respiration.<br>• relate the importance of photosynthesis to the role of producers as the foundation of food webs.<br>• design an investigation from a testable question related to photosynthesis. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. |

## Standard LS.6

| | |
|---|---|
| LS.6 | The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment. Key concepts include<br>a) the carbon, water, and nitrogen cycles;<br>b) interactions resulting in a flow of energy and matter throughout the system;<br>c) complex relationships within terrestrial, freshwater, and marine ecosystems; and<br>d) energy flow in food webs and energy pyramids. |

### Overview

This standard explores the application of the concept of interdependence between organisms and their physical environment. This concept is covered thoroughly in the K–6 standards of the Living Systems strand. The K–6 standards include the concept of interdependence (2.5); relationships in aquatic and terrestrial food chains, trophic levels, food webs, food pyramids, and cycles (3.5 and 4.5); and interactions between the living and nonliving components of an ecosystem (4.5). Terminology used in previous standards includes producer, consumer, decomposer, herbivore, omnivore, carnivore (3.5), and niche (4.5). It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard.

# Standard LS.6

| LS.6 | The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment. Key concepts include<br>a) the carbon, water, and nitrogen cycles;<br>b) interactions resulting in a flow of energy and matter throughout the system;<br>c) complex relationships within terrestrial, freshwater, and marine ecosystems; and<br>d) energy flow in food webs and energy pyramids. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Many important elements and compounds cycle through the living and nonliving components of the environment as a chain of events that continuously repeats.<br>• Materials are recycled and made available through the action of decomposers.<br>• In order to understand how an ecosystem functions, one must understand the concept of a system and be able to envision models of systems.<br>• To analyze the interactions resulting in a flow of energy and matter throughout the ecosystem, one must identify the elements of the system and interpret how energy and matter are used by each organism.<br>• Energy enters an ecosystem through the process of photosynthesis and is passed through the system as one organism eats and is, in turn, eaten. This energy flow can be modeled through relationships expressed in food webs.<br>• The amount of energy available to each successive trophic level (producer, first-order consumer, second-order consumer, third-order consumer) decreases. This can be modeled through an energy pyramid, in which the producers provide the broad base that supports the other interactions in the system. | In order to meet this standard, it is expected that students will<br>• differentiate among key processes in the water, carbon, and nitrogen cycles and relate how organisms, from bacteria and fungi to third-order consumers, function in these cycles.<br>• observe and identify common organisms in ecosystems and collect, record, and chart data concerning the interactions of these organisms (from observations and print and electronic resources).<br>• classify organisms found in local ecosystems as producers or first-, second-, or third-order consumers. Design and construct models of food webs with these organisms.<br>• observe local ecosystems and identify, measure, and classify the living and nonliving components.<br>• identify examples of interdependence in terrestrial, freshwater, and marine ecosystems.<br>• determine the relationship between a population's position in a food web and its size.<br>• apply the concepts of food chains, food webs, and energy pyramids to analyze how energy and matter flow through an ecosystem.<br>• design an investigation from a testable question related to food webs. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. |

## Standard LS.6

| | |
|---|---|
| LS.6 | The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment. Key concepts include<br>a) the carbon, water, and nitrogen cycles;<br>b) interactions resulting in a flow of energy and matter throughout the system;<br>c) complex relationships within terrestrial, freshwater, and marine ecosystems; and<br>d) energy flow in food webs and energy pyramids. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| | • analyze and critique the experimental design of basic investigations related to food webs. |

## Standard LS.7

| | |
|---|---|
| LS.7 | The student will investigate and understand that interactions exist among members of a population. Key concepts include<br>c) competition, cooperation, social hierarchy, territorial imperative; and<br>d) influence of behavior on a population. |

### Overview

This standard applies the concept that each organism exists as a member of a population and interacts with other members of that population in a variety of ways. The term population is introduced in standard 3.6 (“Living Systems” strand). Individuals of a population demonstrate various behavioral adaptations (competition, cooperation, establishment of a social hierarchy, territorial imperative), which allow the population to survive. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard.

## Standard LS.7

| | |
|---|---|
| LS.7 | The student will investigate and understand that interactions exist among members of a population. Key concepts include<br>a) competition, cooperation, social hierarchy, territorial imperative; and<br>b) influence of behavior on a population. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Individual members of a population interact with each other. These interactions include competing with each other for basic resources, mates, territory, and cooperating with each other to meet basic needs.<br>• The establishment of a social order in a population may ensure that labor and resources are adequately shared.<br>• The establishment of a territory ensures that members of a population have adequate habitat to provide for basic resources.<br>• Individual behaviors and group behaviors can influence a population.<br>• Animals exhibit needs for food, water, gases, shelter and space for which they compete. These needs may often be met in a range of conditions. Too much may be as harmful as too little (e.g., too much food or too little water). | In order to meet this standard, it is expected that students will<br>• differentiate between the needs of the individual and the needs of a population.<br>• interpret, analyze, and evaluate data from systematic studies and experiments concerning the interactions among members of a population.<br>• determine the relationship between a population's position in a food web and the types of interactions seen among the individuals of the population.<br>• observe and identify populations in ecosystems and collect, record, chart, and interpret data concerning the interactions of these organisms (from observations and print and electronic resources).<br>• categorize behaviors as examples of competition, cooperation, social hierarchy, or territorial imperative. |

## Standard LS.8

| | |
|---|---|
| LS.8 | The student will investigate and understand interactions among populations in a biological community. Key concepts include<br>f) the relationships among producers, consumers, and decomposers in food webs;<br>g) the relationship between predators and prey;<br>h) competition and cooperation;<br>i) symbiotic relationships; and<br>j) niches. |

### Overview

Life Science standard LS.8 applies the concept of interactions between populations of different species. This standard extends the concepts of prior K–6 standards, including those concerning producers, consumers, and decomposers (3.5); predator and prey (3.6); and niches (4.5). This standard introduces the concept of symbiosis and focuses on the symbiotic relationship between parasite and host. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard.

## Standard LS.8

LS.8 The student will investigate and understand interactions among populations in a biological community. Key concepts include

a) the relationships among producers, consumers, and decomposers in food webs;
b) the relationship between predators and prey;
c) competition and cooperation;
d) symbiotic relationships; and
e) niches.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
| --- | --- |
| The concepts developed in this standard include the following:<br>• Organisms or populations that rely on each other for basic needs form interdependent communities.<br>• Energy resources of a community are shared through the interactions of producers, consumers, and decomposers.<br>• The interaction between a consumer that hunts for another consumer for food is the predator-prey relationship.<br>• In a community, populations interact with other populations by exhibiting a variety of behaviors that aid in the survival of the population.<br>• Organisms may exist as members of a population; populations interact with other populations in a community.<br>• Populations of one species may compete with populations of other species for resources. Populations of one species may also cooperate with populations of other species for resources.<br>• A symbiotic relationship may exist between two or more organisms of different species when they live and work together.<br>• Symbiotic relationships include mutualism (in which both organisms benefit), commensalism (in which one organism benefits and the other is unaffected), and parasitism (in which one organism benefits and the other is harmed).<br>• Each organism fills a specific role or niche in its community. | In order to meet this standard, it is expected that students will<br>• identify the populations of producers, consumers, and decomposers and describe the roles they play in their communities.<br>• interpret, analyze, and evaluate data from systematic studies and experiments concerning the interactions of populations in an ecosystem.<br>• predict the effect of population changes on the food web of a community.<br>• generate predictions based on graphically represented data of predator-prey populations.<br>• generate predictions based on graphically represented data of competition and cooperation between populations.<br>• differentiate between the types of symbiosis and explain examples of each.<br>• infer the niche of organisms from their physical characteristics.<br>• design an investigation from a testable question related to interactions among populations. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. |

## Standard LS.9

| | |
|---|---|
| LS.9 | The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem. Key concepts include<br>d) differences between ecosystems and biomes;<br>e) characteristics of land, marine, and freshwater ecosystems; and<br>f) adaptations that enable organisms to survive within a specific ecosystem. |
| | **Overview**<br>In standard LS.9, students explore the scheme of Earth as a group of living systems. Students are asked to distinguish between ecosystems and biomes. The teacher should be aware that in previous standards, students have explored environments as discrete units or have examined individual components. In standard 3.6 students are introduced to the concept of water environments (pond, marshland, swamp, stream, river, and ocean) and land environments (desert, grassland, rainforest, and forest). It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard. |

# Standard LS.9

| LS.9 | The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem. Key concepts include<br>a) differences between ecosystems and biomes;<br>b) characteristics of land, marine, and freshwater ecosystems; and<br>c) adaptations that enable organisms to survive within a specific ecosystem. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• The living organisms within a specific area and their physical environment define an ecosystem.<br>• Characteristics of land, marine, and freshwater ecosystems vary with respect to biotic and abiotic factors.<br>• The major terrestrial ecosystems are classified into units called biomes — large regions characterized by certain conditions, including a range of climate and ecological communities adapted to those conditions.<br>• Organisms have specific structures, functions, and behaviors that enable them to survive the biotic and abiotic conditions of the particular ecosystem in which they live.<br>• Organisms possess adaptations to both biotic and abiotic factors in their ecosystem that increase their chance of survival. | In order to meet this standard, it is expected that students will<br>• differentiate between ecosystems and biomes.<br>• recognize and give examples of major biomes: desert, forest, grassland, and tundra.<br>• compare and contrast the biotic and abiotic characteristics of land, marine, and freshwater ecosystems.<br>• analyze and describe how specific adaptations enable organisms to survive in a particular ecosystem.<br>• design an investigation from a testable question related to how specific adaptations of organisms allow them to survive in the presence of the biotic and abiotic factors in an ecosystem. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. |

## Standard LS.10

| | |
|---|---|
| LS.10 | The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic, change over time, and respond to daily, seasonal, and long-term changes in their environment. Key concepts include<br>d) phototropism, hibernation, and dormancy;<br>e) factors that increase or decrease population size; and<br>f) eutrophication, climate changes, and catastrophic disturbances. |

### Overview

In standard LS.10, students apply the concept of change over time to several specific situations. As conditions change, organisms, populations, communities, and ecosystems respond to those changes in order to survive. The key concepts are given in a sequence from responses of individual organisms (phototropism, hibernation, and dormancy) to responses of populations (factors that increase or decrease population size) to responses of communities or ecosystems (eutrophication, climate change, and catastrophic disturbances).

The concepts of standard LS.10 focus on the theme of change. Living units respond in various ways to change. A key concept is the understanding of the dynamic nature of living systems as they constantly respond to change. Change is referenced several times in the K–6 standards. In the “Earth Patterns, Cycles, and Change” strand, the following concepts are introduced: natural and human-made things may change over time (K.10); temperature, light, and precipitation bring about changes (1.7); and weather and seasonal changes affect plants, animals, and their surroundings (2.7). The “Life Processes” strand introduces the concept that plants (3.4) and animals (4.4) satisfy life needs and respond to the environment. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard.

# Standard LS.10

| LS.10 | The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic, change over time, and respond to daily, seasonal, and long-term changes in their environment. Key concepts include<br>a) phototropism, hibernation, and dormancy;<br>b) factors that increase or decrease population size; and<br>c) eutrophication, climate changes, and catastrophic disturbances. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Organisms may exist as members of a population; populations interact with other populations in a community; and communities together with the physical environment form ecosystems.<br>• Changes that affect organisms over time may be daily, seasonal, or long term.<br>• Plants may respond to light by growing toward it or away from it, a behavior known as phototropism.<br>• Animals may respond to cold conditions with a period of lowered metabolism, a behavior known as hibernation.<br>• Organisms may respond to adverse conditions with a period of lowered or suspended metabolism, a behavior known as dormancy.<br>• A variety of environmental factors may cause the size of a population to increase or decrease. (This requires students to brainstorm examples of factors and predict the possible effects.)<br>• Long-term changes may affect entire communities and ecosystems. Such large-scale changes include the addition of excess nutrients to the system (eutrophication), which alters environmental balance; dramatic changes in climate; and catastrophic events, such as fire, drought, flood, and earthquakes. | In order to meet this standard, it is expected that students will<br>• relate the responses of organisms to daily, seasonal, or long-term events.<br>• differentiate between ecosystems, communities, populations, and organisms.<br>• predict the effect of climate change on ecosystems, communities, populations, and organisms.<br>• predict the effect of eutrophication on ecosystems, communities, populations, and organisms.<br>• compare and contrast the factors that increase or decrease population size.<br>• classify the various types of changes that occur over time in ecosystems, communities, populations, and organisms, as long term, short term, or seasonal.<br>• design an investigation from a testable question related to change over time in ecosystems, communities, populations, or organisms. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis.<br>• analyze and critique the experimental design of basic investigations related to change over time in ecosystems, communities, populations, and organisms. |

## Standard LS.11

| | |
|---|---|
| LS.11 | The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include<br>a) food production and harvest;<br>b) change in habitat size, quality, or structure;<br>c) change in species competition;<br>d) population disturbances and factors that threaten or enhance species survival; and<br>e) environmental issues. |

### Overview

In this standard, students are called upon to apply their knowledge of human interactions to interpret how these interactions affect ecosystem dynamics. In prior standards in the "Earth Resources" strand of the K–6 standards, students explore a variety of ways in which humans interact with the environment. These include the concepts of waste management (K.11, 1.8); limitations of natural resources and factors that affect environmental quality (1.8, 3.10); Virginia's natural resources (4.8); and public policy decisions relating to the environment (6.9). In this Life Science standard, the student must interpret how human populations can change the balance of nature in ecosystems. They must use their prior knowledge of resources as well as the concepts and skills learned in Life Science standards LS.6 – LS.10. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard.

## Standard LS.11

LS.11 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include

a) food production and harvest;
b) change in habitat size, quality, or structure;
c) change in species competition;
d) population disturbances and factors that threaten or enhance species survival; and
e) environmental issues.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• Ecosystems are dynamic systems. Humans are a natural part of the ecosystem. Humans use the ecosystem to meet their basic needs, such as to obtain food.<br>• Human interaction can directly alter habitat size, the quality of available resources in a habitat, and the structure of habitat components. Such interactions can be positive and/or negative.<br>• Human input can disturb the balance of populations that occur in a stable ecosystem. These disturbances may lead to a decrease or increase in a population. Since populations in an ecosystem are interdependent, these disturbances have a ripple effect throughout the ecosystem.<br>• The interaction of humans with the dynamic ecosystem may lead to issues of concern for continued ecosystem health in areas such as water supply, air quality, energy production, and waste management. | In order to meet this standard, it is expected that students will<br>• identify examples of ecosystem dynamics.<br>• describe the relationship between human food harvest and the ecosystem.<br>• debate the pros and cons of human land use versus ecosystem stability.<br>• compare and contrast population disturbances that threaten and those that enhance species survival.<br>• describe ways that human interaction has altered habitats positively and negatively.<br>• observe the effect of human interaction in local ecosystems and collect, record, chart, and interpret data concerning the effect of interaction (from observations and print and electronic resources).<br>• design an investigation from a testable question related to the relationships between ecosystem dynamics and human activity. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis.<br>• analyze and critique the experimental design of basic investigations related to the relationships between ecosystem dynamics and human activity. |

# Standard LS.12

| | |
|---|---|
| LS.12 | The student will investigate and understand that organisms reproduce and transmit genetic information to new generations. Key concepts include<br>a) the structure and role of DNA;<br>b) the function of genes and chromosomes;<br>c) genotypes and phenotypes;<br>d) characteristics that can and cannot be inherited;<br>e) genetic engineering and its applications; and<br>f) historical contributions and significance of discoveries related to genetics. |

## Overview

In science standard 2.7, students are introduced to the general notion that plants and animals resemble their parents. This Life Science standard is the students' introduction to genetics. It is important for the teacher to understand that the intent of this standard is to provide students with a general overview of the nature of DNA, genes, and chromosomes and the important role they play in the transmission of traits from one generation to another. Students are not expected to understand the specific chemical composition of DNA or the mechanics of transcription and translation. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard.

## Standard LS.12

| LS.12 | The student will investigate and understand that organisms reproduce and transmit genetic information to new generations. Key concepts include<br>a) the structure and role of DNA;<br>b) the function of genes and chromosomes;<br>c) genotypes and phenotypes;<br>d) characteristics that can and cannot be inherited;<br>e) genetic engineering and its applications; and<br>f) historical contributions and significance of discoveries related to genetics. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• DNA is a double helix molecule.<br>• DNA is a molecule that includes different components — sugars, nitrogenous bases, and phosphates. The arrangement of the nitrogenous bases within the double helix forms a chemical code.<br>• Chromosomes are strands of tightly wound DNA. Genes are sections of a chromosome that carry the code for a particular trait. An allele is an alternate form of a gene.<br>• The basic laws of Mendelian genetics explain the transmission of most traits that can be inherited from generation to generation.<br>• A Punnett square is a model used to predict the possible combinations of inherited factors resulting from single trait crosses. (An investigation of dihybrid crosses, multiple alleles, and incomplete dominance should be reserved for high school Biology.)<br>• Dominant traits mask the expression (phenotype) of recessive traits. Genotype is the specific combination of dominant and recessive gene forms.<br>• Traits that are expressed through genes can be inherited. Characteristics that are acquired through environmental influences, such as injuries or practiced skills, cannot be inherited.<br>• In genetic engineering, the genetic code is manipulated to obtain a | In order to meet this standard, it is expected that students will<br>• recognize the appearance of DNA as double helix in shape.<br>• explain that DNA contains coded instructions that store and pass on genetic information from one generation to the next.<br>• explain the necessity of DNA replication for the continuity of life.<br>• explain the relationship among genes, chromosomes, and alleles.<br>• demonstrate variation within a single genetic trait.<br>• distinguish between dominant and recessive traits.<br>• distinguish between genotype and phenotype.<br>• use Punnett squares to predict the possible combinations of inherited factors resulting from single trait crosses.<br>• differentiate between characteristics that can be inherited and those that cannot be inherited.<br>• identify aspects of genetic engineering and supply examples of applications. Evaluate the examples for possible controversial aspects.<br>• describe the contributions of Mendel, Franklin, Watson, and Crick to our basic understanding of genetics. |

## Standard LS.12

| LS.12 | The student will investigate and understand that organisms reproduce and transmit genetic information to new generations. Key concepts include<br>a) the structure and role of DNA;<br>b) the function of genes and chromosomes;<br>c) genotypes and phenotypes;<br>d) characteristics that can and cannot be inherited;<br>e) genetic engineering and its applications; and<br>f) historical contributions and significance of discoveries related to genetics. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| desired product.<br>• Genetic engineering has numerous practical applications in medicine, agriculture, and biology.<br>• A series of contributions and discoveries led to the current level of genetic science. | |

# Standard LS.13

| | |
|---|---|
| LS.13 | The student will investigate and understand that populations of organisms change over time. Key concepts include<br>d) the relationships of mutation, adaptation, natural selection, and extinction;<br>e) evidence of evolution of different species in the fossil record; and<br>f) how environmental influences, as well as genetic variation, can lead to diversity of organisms. |

## Overview

Standard LS.13 explores the concept of evolution through natural selection. Species respond to changes in their environments through adaptation, which is a gradual process that occurs over long periods of time. The progression of these long-term changes is well documented in the fossil record. Evolution, as a big organizing principle of the life sciences, establishes order among the great variety of living things.

There are many misconceptions about evolution; therefore, teachers must be careful to be accurate in their presentation of this scientific theory. One common misconception among students is that they believe that environmental influences on an organism produce changes in that organism that can be passed on to offspring. However, natural selection can only work through the genetic variation that is already present in the population. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (LS.1) in the context of the key concepts presented in this standard.

## Standard LS.13

LS.13 The student will investigate and understand that populations of organisms change over time. Key concepts include

a) the relationships of mutation, adaptation, natural selection, and extinction;
b) evidence of evolution of different species in the fossil record; and
c) how environmental influences, as well as genetic variation, can lead to diversity of organisms.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The concepts developed in this standard include the following:<br>• The mechanisms through which evolution takes place are a related set of processes that include mutation, adaptation, natural selection, and extinction. This results in changes in populations of organisms over time.<br>• Mutations are inheritable changes because a mutation is a change in the DNA code.<br>• Adaptations are structures, functions, or behaviors that enable a species to survive.<br>• Natural selection is the survival and reproduction of the individuals in a population that exhibit the traits that best enable them to survive in their environment.<br>• A mutation may result in a favorable change or adaptation in genetic information that improves a species' ability to exist in its environment, or a mutation may result in an unfavorable change that does not improve or impedes a species' ability to exist in its environment.<br>• The evidence for evolution is drawn from a variety of sources of data, including the fossil record, radiometric dating, genetic information, the distribution of organisms, and anatomical and developmental similarities across species.<br>• Individuals of a population each exhibit a range of variations in a trait as a result of the variations in their genetic codes. These variations may or may not help them survive and reproduce in their environment.<br>• If a species does not include traits that enable it to survive in its environment or to survive changes in the environment, then the species may become extinct. | In order to meet this standard, it is expected that students will<br>• interpret data from simulations that demonstrate selection for a trait belonging to species in various environments.<br>• describe how changes in the environment can bring about changes in a species (adaptation, extinction) through natural selection.<br>• describe and explain how fossils are records of organisms and events in Earth's history.<br>• explain the evidence for evolution from a variety of sources of scientific data.<br>• explain how genetic variations in offspring, which lead to variations in successive generations, can result from the same two parents.<br>• analyze and evaluate data from investigations on variations within a local population.<br>• explain how environmental influences, as well as genetic variation, can lead to diversity of organisms. |

Standard LS.13

## Science Standards of Learning

# Curriculum Framework 2010

# Physical Science

# Standard PS.1

| | |
|---|---|
| PS.1 | The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which<br>a) chemicals and equipment are used safely;<br>b) length, mass, volume, density, temperature, weight, and force are accurately measured;<br>c) conversions are made among metric units, applying appropriate prefixes;<br>d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data;<br>e) numbers are expressed in scientific notation where appropriate;<br>f) independent and dependent variables, constants, controls, and repeated trials are identified;<br>g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted;<br>h) data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted;<br>i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted;<br>j) valid conclusions are made after analyzing data;<br>k) research methods are used to investigate practical problems and questions;<br>l) experimental results are presented in appropriate written form;<br>m) models and simulations are constructed and used to illustrate and explain phenomena; and<br>n) current applications of physical science concepts are used. |

## Overview

The skills described in standard PS.1 are intended to define the "investigate" component of all of the other Physical Science standards (PS.2 – PS.11). The intent of standard PS.1 is that students will continue to develop a range of inquiry skills and achieve proficiency with those skills in the context of the concepts developed in the Physical Science curriculum. Standard PS.1 does not require a discrete unit on scientific investigation because the inquiry skills that make up the standard should be incorporated in all the other Physical Science standards. It is also intended that by developing these skills, students will achieve greater understanding of scientific inquiry and the nature of science, as well as more fully grasp the content-related Standards of Learning concepts. Models, simulations, and current applications are used throughout the course in order to learn and reinforce science concepts.

Across the grade levels, kindergarten through high school, the skills in the first standards form a nearly continuous sequence. It is very important that the Physical Science teacher be familiar with the skills in the sequence leading up to standard PS.1 (LS.1, 6.1, 5.1, 4.1).

# Standard PS.1

| PS.1 | The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which<br>a) chemicals and equipment are used safely;<br>b) length, mass, volume, density, temperature, weight, and force are accurately measured;<br>c) conversions are made among metric units, applying appropriate prefixes;<br>d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data;<br>e) numbers are expressed in scientific notation where appropriate;<br>f) independent and dependent variables, constants, controls, and repeated trials are identified;<br>g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted;<br>h) data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted;<br>i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted;<br>j) valid conclusions are made after analyzing data;<br>k) research methods are used to investigate practical problems and questions;<br>l) experimental results are presented in appropriate written form;<br>m) models and simulations are constructed and used to illustrate and explain phenomena; and<br>n) current applications of physical science concepts are used. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world. The nature of science includes the following concepts of<br>a) the natural world is understandable;<br>b) science is based on evidence - both observational and experimental;<br>c) science is a blend of logic and innovation;<br>d) scientific ideas are durable yet subject to change as new data are collected;<br>e) science is a complex social endeavor; and<br>f) scientists try to remain objective and engage in peer review to help avoid bias. | In order to meet this standard, it is expected that students will<br>• make connections between the components of the nature of science and their investigations and the greater body of scientific knowledge and research.<br>• select appropriate equipment (probeware, triple beam balances, thermometers, metric rulers, graduated cylinders, electronic balances, or spring scales) and utilize correct techniques to measure length, mass, density, weight, volume, temperature, and force.<br>• design a data table that includes space to organize all components of an investigation in a meaningful way, including levels of the independent variable, measured responses of the dependent variable, number of trials, and mathematical means.<br>• record measurements, using the following metric (SI) units: liter, milliliter (cubic centimeters), meter, centimeter, millimeter, grams, |

## Standard PS.1

PS.1 The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which

a) chemicals and equipment are used safely;
b) length, mass, volume, density, temperature, weight, and force are accurately measured;
c) conversions are made among metric units, applying appropriate prefixes;
d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data;
e) numbers are expressed in scientific notation where appropriate;
f) independent and dependent variables, constants, controls, and repeated trials are identified;
g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted;
h) data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted;
i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted;
j) valid conclusions are made after analyzing data;
k) research methods are used to investigate practical problems and questions;
l) experimental results are presented in appropriate written form;
m) models and simulations are constructed and used to illustrate and explain phenomena; and
n) current applications of physical science concepts are used.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| • Systematic investigations require standard measures and consistent and reliable tools. International System of Units (SI or metric) measures, recognized around the world, are a standard way to make measurements.<br>• Systematic investigations require organized reporting of data. The way the data are displayed can make it easier to see important patterns, trends, and relationships. Frequency distributions, scatterplots, line plots, and histograms are powerful tools for displaying and interpreting data.<br>• Investigation not only involves the careful application of systematic (scientific) methodology, but also includes the review and analysis of prior research related to the topic. Numerous sources of information are available from print and electronic sources, and the researcher needs to judge the authority and credibility of the sources.<br>• To communicate the plan of an experiment accurately, the independent variable, dependent variable, and constants must be explicitly defined.<br>• The number of repeated trials needs to be considered in the context of the investigation. Often “controls” are used to establish a standard for | degrees Celsius, and newtons.<br>• recognize metric prefix units and make common metric conversions between the same base metric unit (for example, nanogram to milligram or kilometer to meter).<br>• use a variety of graphical methods to display data; create an appropriate graph for a given set of data; and select the proper type of graph for a given set of data, identify and label the axes, and plot the data points.<br>• gather, evaluate, and summarize information, using multiple and variable resources, and detect bias from a given source.<br>• identify the key components of controlled experiments: hypotheses, independent and dependent variables, constants, controls, and repeated trials.<br>• formulate conclusions that are supported by the gathered data.<br>• apply the methodology of scientific inquiry: begin with a question, |

## Standard PS.1

| PS.1 | The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which<br>a) chemicals and equipment are used safely;<br>b) length, mass, volume, density, temperature, weight, and force are accurately measured;<br>c) conversions are made among metric units, applying appropriate prefixes;<br>d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data;<br>e) numbers are expressed in scientific notation where appropriate;<br>f) independent and dependent variables, constants, controls, and repeated trials are identified;<br>g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted;<br>h) data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted;<br>i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted;<br>j) valid conclusions are made after analyzing data;<br>k) research methods are used to investigate practical problems and questions;<br>l) experimental results are presented in appropriate written form;<br>m) models and simulations are constructed and used to illustrate and explain phenomena; and<br>n) current applications of physical science concepts are used. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| comparing the results of manipulating the independent variable. Controls receive no experimental treatment. Not all experiments have a control, however.<br>• The analysis of data from a systematic investigation may provide the researcher with a basis to reach a reasonable conclusion. Conclusions should not go beyond the evidence that supports them. Additional scientific research may yield new information that affects previous conclusions.<br>• Different kinds of problems and questions require differing approaches and research. Scientific methodology almost always begins with a question, is based on observation and evidence, and requires logic and reasoning. Not all systematic investigations are experimental.<br>• It is important to communicate systematically the design and results of an investigation so that questions, procedures, tools, results, and conclusions can be understood and replicated.<br>• Some useful applications of physical science concepts are in the area of materials science (e.g., metals, ceramics, and semiconductors). | design an investigation, gather evidence, formulate an answer to the original question, communicate the investigative process and results, and realize this methodology does not always follow a prescribed sequence.<br>• communicate in written form the following information about investigations: the purpose/problem of the investigation, procedures, materials, data and/or observations, graphs, and an interpretation of the results.<br>• describe how creativity comes into play during various stages of scientific investigations.<br>• use current technologies to model and simulate experimental conditions.<br>• recognize examples of the use of nanotechnology and its applications. |

## Standard PS.1

PS.1 The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which

a) chemicals and equipment are used safely;
b) length, mass, volume, density, temperature, weight, and force are accurately measured;
c) conversions are made among metric units, applying appropriate prefixes;
d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data;
e) numbers are expressed in scientific notation where appropriate;
f) independent and dependent variables, constants, controls, and repeated trials are identified;
g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted;
h) data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted;
i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted;
j) valid conclusions are made after analyzing data;
k) research methods are used to investigate practical problems and questions;
l) experimental results are presented in appropriate written form;
m) models and simulations are constructed and used to illustrate and explain phenomena; and
n) current applications of physical science concepts are used.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| • Nanotechnology is the study of materials at the molecular (atomic) scale. Items at this scale are so small they are no longer visible with the naked eye. Nanotechnology has shown that the behavior and properties of some substances at the nanoscale (a nanometer is one-billionth of a meter) contradict how they behave and what their properties are at the visible scale.<br>• New discoveries based on nanoscience investigations have allowed the production of superior new materials with improved properties (e.g., computers, cell phones). | |

# Standard PS.2

| | |
|---|---|
| PS.2 | The student will investigate and understand the nature of matter. Key concepts include<br>a) the particle theory of matter;<br>b) elements, compounds, mixtures, acids, bases, and salts;<br>c) solids, liquids, and gases;<br>d) physical properties;<br>e) chemical properties; and<br>f) characteristics of types of matter based on physical and chemical properties. |

## Overview

The concepts in PS.2 build upon several science standards from previous grades, including K.4, 1.3, 2.3, 3.3, 5.4, and 6.4. These standards introduce and develop basic ideas about the characteristics and structure of matter. In PS.2, the ideas and terminology continue to be expanded and treated in greater depth, including more mathematical application. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

## Standard PS.2

| PS.2 | The student will investigate and understand the nature of matter. Key concepts include<br>a) the particle theory of matter;<br>b) elements, compounds, mixtures, acids, bases, and salts;<br>c) solids, liquids, and gases;<br>d) physical properties;<br>e) chemical properties; and<br>f) characteristics of types of matter based on physical and chemical properties. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• Matter is anything that has mass and occupies space. All matter is made up of small particles called atoms. Matter can exist as a solid, a liquid, a gas, or plasma.<br>• Matter can be classified as elements, compounds, and mixtures. The atoms of any element are alike but are different from atoms of other elements. Compounds consist of two or more elements that are chemically combined in a fixed ratio. Mixtures also consist of two or more substances, but the substances are not chemically combined.<br>• Compounds can be classified in several ways, including:<br>- acids, bases, salts<br>- inorganic and organic compounds.<br>• Acids make up an important group of compounds that contain hydrogen ions. When acids dissolve in water, hydrogen ions ($H^+$) are released into the resulting solution. A base is a substance that releases hydroxide ions ($OH^-$) into solution. pH is a measure of the hydrogen ion concentration in a solution. The pH scale ranges from 0–14. Solutions with a pH lower than 7 are acidic; solutions with a pH greater than 7 are basic. A pH of 7 is neutral. When an acid reacts with a base, a salt is formed, along with water.<br>• Matter can be described by its physical properties, which include shape, density, solubility, odor, melting point, boiling point, and color. Some | In order to meet this standard, it is expected that students will<br>• describe the particle theory of matter.<br>• describe how to determine whether a substance is an element, compound, or mixture.<br>• define compounds as inorganic or organic. (All organic compounds contain carbon).<br>• describe what a salt is and explain how salts form.<br>• describe the properties of solids, liquids, gases, and plasma.<br>• distinguish between physical properties (i.e., shape, density, solubility, odor, melting point, boiling point, and color) and chemical properties (i.e., acidity, basicity, combustibility, and reactivity).<br>• find the mass and volume of substances and calculate and compare their densities.<br>• analyze the pH of a solution and classify it as acidic, basic, or neutral.<br>• determine the identity of an unknown substance by comparing its properties to those of known substances.<br>• design an investigation from a testable question related to physical and chemical properties of matter. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. (Students should be able to use the inquiry skills represented |

## Standard PS.2

| | |
|---|---|
| PS.2 | The student will investigate and understand the nature of matter. Key concepts include<br>a) the particle theory of matter;<br>b) elements, compounds, mixtures, acids, bases, and salts;<br>c) solids, liquids, and gases;<br>d) physical properties;<br>e) chemical properties; and<br>f) characteristics of types of matter based on physical and chemical properties. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| physical properties, such as density, boiling point, and solubility, are characteristic of a specific substance and do not depend on the size of the sample. Characteristic properties can be used to identify unknown substances.<br>• Equal volumes of different substances usually have different masses.<br>• Matter can also be described by its chemical properties, which include acidity, basicity, combustibility, and reactivity. A chemical property indicates whether a substance can undergo a chemical change. | in PS.1 and LS.1 to compose a clear hypothesis, create an organized data table, identify variables and constants, record data correctly, construct appropriate graphs, analyze data, and draw reasonable conclusions.) |

## Standard PS.3

| | |
|---|---|
| PS.3 | The student will investigate and understand the modern and historical models of atomic structure. Key concepts include<br>a) the contributions of Dalton, Thomson, Rutherford, and Bohr in understanding the atom; and<br>b) the modern model of atomic structure. |

### Overview

PS.3 builds upon science standards 3.3, 5.4, and 6.4, which introduce basic concepts and terminology related to the atom. PS.3 focuses more specifically on the basic structure of the atom and how models have been and are used to explain atomic structure. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

## Standard PS.3

| PS.3 | The student will investigate and understand the modern and historical models of atomic structure. Key concepts include<br>a) the contributions of Dalton, Thomson, Rutherford, and Bohr in understanding the atom; and<br>b) the modern model of atomic structure. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• Many scientists have contributed to our understanding of atomic structure.<br>• The atom is the basic building block of matter and consists of subatomic particles (proton, neutron, electron, and quark) that differ in their location, charge, and relative mass. Protons and neutrons are made up of smaller particles called quarks.<br>• Size at the atomic level is measured on the nanoscale.<br>• Scientists use models to help explain the structure of the atom. Their understanding of the structure of the atom continues to evolve. Two models commonly used are the Bohr and the "electron cloud" (Quantum Mechanics) models. The Bohr model does not depict the three-dimensional aspect of an atom, and it implies that electrons are in static orbits. The "electron cloud" model better represents our current understanding of the structure of the atom. | In order to meet this standard, it is expected that students will<br>• describe the historical development of the concept of the atom and the contributions of Dalton, Thomson, Rutherford, Bohr and other scientists (Schrödinger).<br>• differentiate among the three basic particles in the atom (proton, neutron, and electron) and their charges, relative masses, and locations.<br>• compare the Bohr atomic model to the electron cloud model with respect to its ability to represent accurately the three-dimensional structure of the atom. |

# Standard PS.4

| | |
|---|---|
| PS.4 | The student will investigate and understand the organization and use of the periodic table of elements to obtain information. Key concepts include<br>a) symbols, atomic number, atomic mass, chemical families (groups), and periods;<br>b) classification of elements as metals, metalloids, and nonmetals; and<br>c) formation of compounds through ionic and covalent bonding. |

## Overview

PS.4 formally introduces the periodic table of elements. This standard builds upon concepts of the atom presented in science standard 6.4. Standard PS.4 focuses on a student's ability to look at the organization of the periodic table and obtain information from it. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

## Standard PS.4

| | |
|---|---|
| PS.4 | The student will investigate and understand the organization and use of the periodic table of elements to obtain information. Key concepts include<br>a) symbols, atomic number, atomic mass, chemical families (groups), and periods;<br>b) classification of elements as metals, metalloids, and nonmetals; and<br>c) formation of compounds through ionic and covalent bonding. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• There are more than 110 known elements. No element with an atomic number greater than 92 is found naturally in measurable quantities on Earth. The remaining elements are artificially produced in a laboratory setting. Elements combine in many ways to produce compounds that make up all other substances on Earth.<br>• The periodic table of elements is a tool used to organize information about the elements. Each box in the periodic table contains information about the structure of an element.<br>• An atom's identity is directly related to the number of protons in its nucleus. This is the basis for the arrangement of atoms on the periodic table of elements.<br>• The vertical columns in the table are called groups or families. The horizontal rows are called periods.<br>• Elements in the same column (family) of the periodic table contain the same number of electrons in their outer energy levels. This gives rise to their similar properties and is the basis of periodicity — the repetitive pattern of properties such as boiling point across periods on the table.<br>• The periodic table of elements is an arrangement of elements according to atomic number and properties. The information can be used to predict chemical reactivity. The boxes for all of the elements are arranged in increasing order of atomic number. The elements have an increasing nonmetallic character as one reads from left to right | In order to meet this standard, it is expected that students will<br>• use the periodic table to obtain the following information about the atom of an element:<br>- symbol<br>- atomic number<br>- atomic mass<br>- state of matter at room temperature<br>- number of outer energy level (valence) electrons.<br>• describe the organization of the periodic table in terms of<br>- atomic number<br>- metals, metalloids, and nonmetals<br>- groups/families vs. periods.<br>• recognize that an atom's identity is related to the number of protons in its nucleus.<br>• categorize a given element as metal, nonmetal, or metalloid.<br>• given a chemical formula of a compound, identify the elements and the number of atoms of each that comprise the compound.<br>• recognize that the number of electrons in the outermost energy level determines an element's chemical properties or chemical reactivity.<br>• describe the difference between ionic and covalent bonding.<br>• predict what kind of bond (ionic or covalent) will likely form when metals and nonmetals are chemically combined. |

## Standard PS.4

| PS.4 | The student will investigate and understand the organization and use of the periodic table of elements to obtain information. Key concepts include<br>a) symbols, atomic number, atomic mass, chemical families (groups), and periods;<br>b) classification of elements as metals, metalloids, and nonmetals; and<br>c) formation of compounds through ionic and covalent bonding. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| across the table. Along the stair-step line are the metalloids, which have properties of both metals and nonmetals.<br>• The nonmetals are located to the right of the stair-step line on the periodic table.<br>• Metals tend to lose electrons in chemical reactions, forming positive ions. Nonmetals tend to gain electrons in chemical reactions, forming negative ions.<br>• Gaining or losing electrons makes an atom an ion.<br>• Gaining or losing neutrons makes an atom an isotope. However, gaining or losing a proton makes an atom into a completely different element.<br>• Atoms react to form chemically stable substances that are held together by chemical bonds and are represented by chemical formulas. To become chemically stable, atoms gain, lose, or share electrons.<br>• Compounds are formed when elements react chemically. When a metallic element reacts with a nonmetallic element, their atoms gain and lose electrons respectively, forming ionic bonds. Generally, when two nonmetals react, atoms share electrons, forming covalent (molecular) bonds. | |

## Standard PS.5

| | |
|---|---|
| PS.5 | The student will investigate and understand changes in matter and the relationship of these changes to the Law of Conservation of Matter and Energy. Key concepts include<br>a) physical changes;<br>b) chemical changes; and<br>c) nuclear reactions. |
| | **Overview**<br>This standard focuses on the concept that matter and energy can be changed in different ways, but the total amount of mass and energy is conserved. Students have previously investigated physical and chemical changes. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard. |

# Standard PS.6

| PS.5 | The student will investigate and understand changes in matter and the relationship of these changes to the Law of Conservation of Matter and Energy. Key concepts include<br>a) physical changes;<br>b) chemical changes; and<br>c) nuclear reactions. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• Matter can undergo physical and chemical changes. In physical changes, the chemical composition of the substances does not change. In chemical changes, different substances are formed. Chemical changes are often affected by the surface area/volume ratio of the materials involved in the change.<br>• The Law of Conservation of Matter (Mass) states that regardless of how substances within a closed system are changed, the total mass remains the same. The Law of Conservation of Energy states that energy cannot be created or destroyed but only changed from one form to another.<br>• A chemical equation represents the changes that take place in a chemical reaction. The chemical formulas of the reactants are written on the left, an arrow indicates a change to new substances, and the chemical formulas of the products are written on the right. Chemical reactions are classified into two broad types: ones in which energy is released (exothermic) and ones in which energy is absorbed (endothermic). (The study of synthesis, decomposition, and replacement reactions can be reserved for high school chemistry.)<br>• Another type of change occurs in nuclear reactions. Nuclear energy is the energy stored in the nucleus of an atom. This energy can be released by joining nuclei together (fusion) or by splitting nuclei (fission), resulting in the conversion of minute amounts of matter into energy. In nuclear reactions, a small amount of matter produces a large amount of energy. However, there are potential negative effects of using nuclear energy, including radioactive nuclear waste storage and disposal. | In order to meet this standard, it is expected that students will<br>• compare and contrast physical, chemical, and nuclear changes.<br>• identify the reactants and products in a given chemical equation formula.<br>• design an investigation that illustrates physical and chemical changes.<br>• given chemical formulas, write and balance simple chemical equations.<br>• analyze experimental data to determine whether it supports the Law of Conservation of Mass.<br>• recognize that some types of chemical reactions require continuous input of energy (endothermic) and others release energy (exothermic).<br>• describe, in simple terms, the processes that release nuclear energy (i.e., nuclear fission and nuclear fusion). Create a simple diagram to summarize and compare and contrast these two types of nuclear energy.<br>• evaluate the positive and negative effects of using nuclear energy. |

## Standard PS.6

| | |
|---|---|
| PS.6 | The student will investigate and understand forms of energy and how energy is transferred and transformed. Key concepts include<br>a) potential and kinetic energy; and<br>b) mechanical, chemical, electrical, thermal, radiant and nuclear energy. |

### Overview

The concepts in PS.6 build upon several science standards from previous grades, including 4.2, 4.3, 6.2, and 6.4. These standards introduce and develop basic ideas about states and forms of energy. At the sixth-grade level, this sequence culminates with the idea about energy transformations. In PS.6, concepts about energy forms, energy transformations, and potential and kinetic energy continue to be expanded and treated in greater depth, including more mathematical application. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

## Standard PS.6

| | |
|---|---|
| PS.6 | The student will investigate and understand forms of energy and how energy is transferred and transformed. Key concepts include<br>a) potential and kinetic energy; and<br>b) mechanical, chemical, electrical, thermal, radiant and nuclear energy. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• Energy is the ability to do work.<br>• Energy exists in two states. Potential energy is stored energy based on position or chemical composition. Kinetic energy is energy of motion. Students should know that the amount of potential energy associated with an object depends on its position. The amount of kinetic energy depends on the mass and velocity of the moving object.<br>• Important forms of energy include radiant, thermal, chemical, electrical, mechanical, and nuclear energy. Visible light is a form of radiant energy and sound is a form of mechanical energy.<br>• Energy can be transformed from one type to another. In any energy conversion, some of the energy is lost to the environment as thermal energy. | In order to meet this standard, it is expected that students will<br>• differentiate between potential and kinetic energy.<br>• use diagrams or concrete examples to compare relative amounts of potential and kinetic energy.<br>• identify and give examples of common forms of energy.<br>• design an investigation or create a diagram to illustrate energy transformations. |

## Standard PS.7

| | |
|---|---|
| PS.7 | The student will investigate and understand temperature scales, heat, and thermal energy transfer. Key concepts include<br>a) Celsius and Kelvin temperature scales and absolute zero;<br>b) phase change, freezing point, melting point, boiling point, vaporization, and condensation;<br>c) conduction, convection, and radiation; and<br>d) applications of thermal energy transfer. |

### Overview

This standard focuses on how thermal energy is transferred. Concepts introduced in previous grades and related to the states of matter are presented in standards 2.3 and 5.4. More complex concepts and terminology related to phase changes are introduced in PS.7, including the distinction between heat and temperature. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

## Standard PS.7

| | |
|---|---|
| PS.7 | The student will investigate and understand temperature scales, heat, and thermal energy transfer. Key concepts include<br>a) Celsius and Kelvin temperature scales and absolute zero;<br>b) phase change, freezing point, melting point, boiling point, vaporization, and condensation;<br>c) conduction, convection, and radiation; and<br>d) applications of thermal energy transfer. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• Heat and temperature are not the same thing. Heat is the transfer of thermal energy between substances of different temperature. As thermal energy is added, the temperature of a substance increases.<br>• Temperature is a measure of the average kinetic energy of the molecules of a substance. Increased temperature means greater average kinetic energy of the molecules in the substance being measured, and most substances expand when heated. The temperature of absolute zero (–273$^{o}$C/0 K) is the theoretical point at which molecular motion stops.<br>• Atoms and molecules are perpetually in motion.<br>• The transfer of thermal energy occurs in three ways: by conduction, by convection, and by radiation.<br>• As thermal energy is added to or taken away from a system, the temperature does not always change. There is no change in temperature during a phase change (freezing, melting, condensing, evaporating, boiling, and vaporizing) as this energy is being used to make or break bonds between molecules. | In order to meet this standard, it is expected that students will<br>• distinguish between heat and temperature.<br>• compare and contrast Celsius and Kelvin temperature scales and describe absolute zero.<br>• illustrate and explain the effect of the addition or subtraction of thermal energy on the motion of molecules.<br>• analyze a time/temperature graph of a phase change experiment to determine the temperature at which the phase change occurs (freezing point, melting point, or boiling point).<br>• compare and contrast methods of thermal energy transfer (conduction, convection, and radiation) and provide and explain common examples.<br>• explain, in simple terms, how the principle of thermal energy transfer applies to heat engines, thermostats, refrigerators, heat pumps, and geothermal systems.<br>• design an investigation from a testable question related to thermal energy transfer. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. |

## Standard PS.8

| | |
|---|---|
| PS.8 | The student will investigate and understand the characteristics of sound waves. Key concepts include<br>a) wavelength, frequency, speed, amplitude, rarefaction, and compression;<br>b) resonance;<br>c) the nature of compression waves; and<br>d) technological applications of sound. |

### Overview

The focus of this standard is the mechanical wave-like nature of sound and some examples of its application. Sound is introduced in science standard 5.2, and it is expected that standard PS.8 will build upon and expand the concepts of the earlier standard. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

## Standard PS.8

| PS.8 | The student will investigate and understand the characteristics of sound waves. Key concepts include<br>a) wavelength, frequency, speed, amplitude, rarefaction, and compression;<br>b) resonance;<br>c) the nature of compression waves; and<br>d) technological applications of sound. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• Sound is produced by vibrations and is a type of mechanical energy. Sound travels in compression waves and at a speed much slower than light. It needs a medium (solid, liquid, or gas) in which to travel. In a compression wave, matter vibrates in the same direction in which the wave travels.<br>• All waves exhibit certain characteristics: wavelength, frequency, and amplitude. As wavelength increases, frequency decreases.<br>• The speed of sound depends on two things: the medium through which the waves travel and the temperature of the medium.<br>• Resonance is the tendency of a system to vibrate at maximum amplitude at certain frequencies.<br>• A compression (longitudinal) wave consists of a repeating pattern of compressions and rarefactions. Wavelength is measured as the distance from one compression to the next compression or the distance from one rarefaction to the next rarefaction.<br>• Reflection and interference patterns are used in ultrasonic technology, including sonar and medical diagnosis. | In order to meet this standard, it is expected that students will<br>• determine the relationship between frequency and wavelength.<br>• analyze factors that determine the speed of sound through various materials and interpret graphs and charts that display this information.<br>• identify examples illustrating resonance (e.g., musical instruments, Tacoma Narrows Bridge, crystal stemware).<br>• model a compression (longitudinal) wave and diagram, label, and describe the basic components: wavelength, compression, rarefaction, and frequency.<br>• describe technological applications of sound waves and generally how each application functions.<br>• design an investigation from a testable question related to sound. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. |

# Standard PS.9

| | |
|---|---|
| PS.9 | The student will investigate and understand the characteristics of transverse waves. Key concepts include<br>a) wavelength, frequency, speed, amplitude, crest, and trough;<br>b) the wave behavior of light;<br>c) images formed by lenses and mirrors;<br>d) the electromagnetic spectrum; and<br>e) technological applications of light. |

## Overview

This standard focuses on the nature of light and its applications. It builds upon standard 5.3, in which students investigate the characteristics of visible light. Standard PS.9 introduces students to the wave behavior of light. The speed of light in a vacuum is a constant. Light can change speed and direction as a result of moving from one medium to another. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

## Standard PS.9

| PS.9 | The student will investigate and understand the characteristics of transverse waves. Key concepts include<br>a) wavelength, frequency, speed, amplitude, crest, and trough;<br>b) the wave behavior of light;<br>c) images formed by lenses and mirrors;<br>d) the electromagnetic spectrum; and<br>e) technological applications of light. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• Visible light is a form of radiant energy that moves in transverse waves.<br>• All transverse waves exhibit certain characteristics: wavelength, crest, trough, frequency, and amplitude. As wavelength increases, frequency decreases. There is an inverse relationship between frequency and wavelength.<br>• Radiant energy travels in straight lines until it strikes an object where it can be reflected, absorbed, or transmitted. As visible light travels through different media, it undergoes a change in speed that may result in refraction.<br>• Electromagnetic waves are arranged on the electromagnetic spectrum by wavelength. All types of electromagnetic radiation travel at the speed of light, but differ in wavelength. The electromagnetic spectrum includes gamma rays, X-rays, ultraviolet, visible light, infrared, and radio and microwaves.<br>• Radio waves are the lowest energy waves and have the longest wavelength and the lowest frequency. Gamma rays are the highest energy waves and have the shortest wavelength and the highest frequency. Visible light lies in between and makes up only a small portion of the electromagnetic spectrum.<br>• Plane, concave, and convex mirrors all reflect light. Convex mirrors diverge light and produce a smaller, upright image. Concave mirrors converge light and produce an upright, magnified image if close and an | In order to meet this standard, it is expected that students will<br>• model a transverse wave and draw and label the basic components. Explain wavelength, amplitude, frequency, crest, and trough.<br>• describe the wave behavior of visible light (refraction, reflection, diffraction, and interference).<br>• design an investigation to illustrate the behavior of visible light – reflection and refraction. Describe how reflection and refraction occur.<br>• identify the images formed by lenses and mirrors.<br>• compare the various types of electromagnetic waves in terms of wavelength, frequency, and energy.<br>• describe an everyday application of each of the major forms of electromagnetic energy. |

## Standard PS.9

| | |
|---|---|
| PS.9 | The student will investigate and understand the characteristics of transverse waves. Key concepts include<br>a) wavelength, frequency, speed, amplitude, crest, and trough;<br>b) the wave behavior of light;<br>c) images formed by lenses and mirrors;<br>d) the electromagnetic spectrum; and<br>e) technological applications of light. |

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| inverted, smaller image if far away.<br>• Concave and convex lenses refract light. Concave lenses converge light. Convex lenses diverge light.<br>• Diffraction is when light waves strike an obstacle and new waves are produced.<br>• Interference takes place when two or more waves overlap and combine as a result of diffraction. | |

## Standard PS.10

| | |
|---|---|
| PS.10 | The student will investigate and understand the scientific principles of work, force, and motion. Key concepts include<br>a) speed, velocity, and acceleration;<br>b) Newton's laws of motion;<br>c) work, force, mechanical advantage, efficiency, and power; and<br>d) technological applications of work, force, and motion. |
| | **Overview**<br>Standard PS.10 builds upon the concepts of simple machines, force, and work introduced in science standards 3.2 and 4.2. Standard PS.10 reviews and expands these basic ideas and introduces students to more mathematical concepts of motion. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard. |

# Standard PS.10

PS.10 The student will investigate and understand the scientific principles of work, force, and motion. Key concepts include
a) speed, velocity, and acceleration;
b) Newton's laws of motion;
c) work, force, mechanical advantage, efficiency, and power; and
d) technological applications of work, force, and motion.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• Acceleration is the change in velocity per unit of time. An object moving with constant velocity has no acceleration. A decrease in velocity is negative acceleration or deceleration. A distance-time graph for acceleration is always a curve. Objects moving with circular motion are constantly accelerating because direction (and hence velocity) is constantly changing.<br>• Newton's three laws of motion describe the motion of all common objects.<br>• Mass and weight are not equivalent. Mass is the amount of matter in a given substance. Weight is a measure of the force due to gravity acting on a mass. Weight is measured in newtons.<br>• A force is a push or pull. Force is measured in newtons. Force can cause objects to move, stop moving, change speed, or change direction. Speed is the change in position of an object per unit of time. Velocity may have a positive or a negative value depending on the direction of the change in position, whereas speed always has a positive value and is nondirectional.<br>• Work is done when an object is moved through a distance in the direction of the applied force.<br>• A simple machine is a device that makes work easier. Simple machines have different purposes: to change the effort needed (mechanical advantage), to change the direction or distance through which the force is applied, to change the speed at which the resistance moves, or a | In order to meet this standard, it is expected that students will<br>• make measurements to calculate the speed of a moving object.<br>• apply the concepts of speed, velocity, and acceleration when describing motion.<br>• differentiate between mass and weight.<br>• identify situations that illustrate each Law of Motion.<br>• explain how force, mass, and acceleration are related.<br>• apply the concept of mechanical advantage to test and explain how a machine makes work easier.<br>• make measurements to calculate the work done on an object.<br>• make measurements to calculate the power of an object.<br>• solve basic problems given the following formulas:<br>Speed = distance/time ($s = d/t$)<br>Force = mass × acceleration ($F = ma$)<br>Work = force × distance ($W = Fd$)<br>Power = work/time ($P = W/t$).<br>• explain how the concepts of work, force, and motion apply to everyday uses and current technologies. |

## Standard PS.10

PS.10 The student will investigate and understand the scientific principles of work, force, and motion. Key concepts include

a) speed, velocity, and acceleration;
b) Newton's laws of motion;
c) work, force, mechanical advantage, efficiency, and power; and
d) technological applications of work, force, and motion.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
| --- | --- |
| combination of these. Due to friction, the work put into a machine is always greater than the work output. The ratio of work output to work input is called efficiency.<br>• Mathematical formulas are used to calculate speed, force, work, and power. | |

## Standard PS.11

| | |
|---|---|
| PS.11 | The student will investigate and understand basic principles of electricity and magnetism. Key concepts include<br>a) static electricity, current electricity, and circuits;<br>b) relationship between a magnetic field and an electric current;<br>c) electromagnets, motors, and generators and their uses; and<br>d) conductors, semiconductors, and insulators. |

### Overview

Science standards 4.3 provide students with a strong foundation in the characteristics of electricity and simple circuits. Students in fourth grade construct series and parallel circuits and make electromagnets. Standard PS.11 is intended to provide a more in-depth and mathematical focus on circuits, current, static electricity, and the relationship between electricity and magnetism. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

## Standard PS.11

PS.11 The student will investigate and understand basic principles of electricity and magnetism. Key concepts include

a) static electricity, current electricity, and circuits;
b) relationship between a magnetic field and an electric current;
c) electromagnets, motors, and generators and their uses.; and
d) conductors, semiconductors, and insulators.

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| The critical scientific concepts developed in this standard include the following:<br>• Several factors affect how much electricity can flow through a system. Resistance is a property of matter that affects the flow of electricity. Some substances have more resistance than others.<br>• Friction can cause electrons to be transferred from one object to another. These static electrical charges can build up on an object and be discharged slowly or rapidly. This is often called static electricity.<br>• Electricity is related to magnetism. Magnetic fields can produce electrical current in conductors. Electricity can produce a magnetic field and cause iron and steel objects to act like magnets.<br>• Electromagnets are temporary magnets that lose their magnetism when the electric current is removed. Both a motor and a generator have magnets (or electromagnets) and a coil of wire that creates another magnetic field.<br>• A generator is a device that converts mechanical energy into electrical energy. Most of the electrical energy we use comes from generators. Electric motors convert electrical energy into mechanical energy that is used to do work. Examples of motors include those in many household appliances, such as blenders and washing machines.<br>• A conductor is a material that transfers an electric current well. An insulator is material that does not transfer an electric current. A semiconductor is in-between a conductor and an insulator.<br>• The diode is a semiconductor device that acts like a one way valve to control the flow of electricity in electrical circuits. Solar cells are made of semiconductor diodes that produce direct current (DC) when visible light, infrared light (IR), or ultraviolet (UV) energy strikes them. Light | In order to meet this standard, it is expected that students will<br>• design an investigation to illustrate the effects of static electricity.<br>• construct and compare series and parallel circuits.<br>• create an electromagnet and explain how it works.<br>• explain the relationship between a magnetic field and an electric current.<br>• construct simple circuits to determine the relationship between voltage, resistance, and current.<br>• compare and contrast generators and motors and how they function.<br>• identify situations in everyday life in which motors and generators are used.<br>• provide examples of materials that are good conductors, semiconductors, and insulators.<br>• identify current applications of semiconductors and their uses (e.g., diodes and transistors). |

## Standard PS.11

| PS.11 | The student will investigate and understand basic principles of electricity and magnetism. Key concepts include<br>a) static electricity, current electricity, and circuits;<br>b) relationship between a magnetic field and an electric current;<br>c) electromagnets, motors, and generators and their uses.; and<br>d) conductors, semiconductors, and insulators. |
|---|---|

| Essential Understandings | Essential Knowledge, Skills, and Processes |
|---|---|
| emitting diodes (LED) emit visible light or infrared radiation when current passes through them. An example is the transmitter in an infrared TV remote or the lighting course behind the screen in an LED TV or notebook computer screen.<br><br>• Transistors are semiconductor devices made from silicon, and other semiconductors. They are used to amplify electrical signals (in stereos, radios, etc.) or to act like a light switch turning the flow of electricity on and off. | |