Science Standards of Learning Crosswalk between the 2018 and 2010 Standards

Virginia Department of Education

July 2019

Kindergarten Cross Walk

2018 Theme: Using my senses to understand my world

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- K-6 themes have been built into the standards to allow for a more cohesive approach to the instruction of science concepts.
- The sections of Life Processes and Living Systems have been combined into one section, Living Systems and Processes.
- The sections of Interrelationships in Earth/Space Systems and Earth Patterns, Cycles, and Change have been combined into one section, Earth and Space Systems.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Kindergarten science:

- The development of force builds from concrete to more abstract K-5. The development of force in Kindergarten begins with the effect of pushes and pulls on the motion of object.
- The study of senses was moved from Scientific Investigation to Living Systems and Processes.
- The concept of light was expanded to include its ability to increase temperature and cause shadows.
- The standard on patterns (K.9) was revised to include daily weather, seasonal changes, and day and night. Animal and plant growth (life cycles) moved to K.7.
- Observations of speed and position were removed from student investigations of physical properties (K.3)
- Magnets were moved to second grade with gravity as indirect forces.
- Standard K.11 was revised to reflect the use of resources in daily life.

2010	2018
 K.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which a) basic characteristics or properties of objects are identified by direct observation; b) observations are made from multiple positions to achieve different perspectives; c) a set of objects is sequenced according to size; d) a set of objects is separated into two groups based on a single physical characteristic; e) nonstandard units are used to measure the length, mass, and volume of common objects; f) observations and predictions are made for an unseen member in a sequence of objects; g) a question is developed and predictions are made from one or more observations; h) observations are recorded; i) picture graphs are constructed; j) unusual or unexpected results in an activity are recognized; and k) objects are described both pictorially and verbally. 	 K.1 The student will demonstrate an understanding of scientific and engineering practices by a) asking questions and defining problems ask questions based on observations identify a problem based on need make predictions based on observations b) planning and carrying out investigations make observations to collect data identify characteristics and properties of objects by observations measure relative length and weight of common objects record information from investigation c) interpreting, analyzing, and evaluating data describe patterns classify and/or sequence objects based on a single physical characteristic or property organize and represent data read and interpret data in object graphs, picture graphs, and tables d) constructing and critiquing conclusions and explanations make simple conclusions based on data or observations developing and using models distinguish between a model and an actual object obtaining, evaluating, and communicating information communicate observations using pictures, drawings, and/or sneech
 K.3 The student will investigate and understand that magnets have an effect on some materials, make some things move without touching them, and have useful applications. Key concepts include a) magnetism and its effects; and b) useful applications of magnetism. 	 K.2 The student will investigate and understand that pushes and pulls affect the motion of objects. Key ideas include a) pushes and pulls can cause an object to move; b) pushes and pulls can change the direction of an object; and c) changes in motion are related to the strength of the push or pull.

2010		2018	
K.4	The student will investigate and understand that the position, motion, and physical properties of an object can be described. Key concepts include a) colors of objects; b) shapes and forms of objects; c) textures and feel of objects; d) relative sizes and weights of objects; and e) relative positions and speed of objects.	K.3	 The student will investigate and understand that physical properties of an object can be described. Properties include a) colors; b) shapes and forms; c) textures and feel; and d) relative sizes and weights of objects.
K.5 K.2	The student will investigate and understand that water flows and has properties that can be observed and tested. Key concepts include a) water occurs in different phases; b) water flows downhill; and c) some materials float in water, while others sink. The student will investigate and understand that humans have senses that allow them to seek find take in and	K.4 K.5	 The student will investigate and understand that water is important in our daily lives and has properties. Key ideas include a) water has many uses; b) water can be found in many places; c) water occurs in different phases; and d) water flows downhill. The students will investigate and understand that senses allow humans to seek find take in and react or respond to different
	 react or respond to information in order to learn about their surroundings. Key concepts include a) the five senses and corresponding sensing organs; and b) sensory descriptors used to describe common objects and phenomena. 		 a) the five basic senses correspond to specific human body structures; and b) senses are used in our daily lives.
K.6	 The student will investigate and understand the differences between living organisms and nonliving objects. Key concepts include a) all things can be classified as living or nonliving; and b) living organisms have certain characteristics that distinguish them from nonliving objects including growth, movement, response to the environment, having offspring, and the need for food, air, and water. 	K.6	 The student will investigate and understand that there are differences between living organisms and nonliving objects. Key ideas include a) all things can be classified as living or nonliving; and b) living organisms have certain characteristics that distinguish them from nonliving objects.
K.7	The student will investigate and understand basic needs and life processes of plants and animals. Key concepts include	K.7	The student will investigate and understand that plants and animals have basic needs and life processes. Key ideas includea) living things need adequate food, water, shelter, air, and space to survive;

	2010		2018
	a) animals need adequate food, water, shelter, air, and		b) plants and animals have life cycles; and
	b) plants need nutrients, water, air, light, and a place to		to their parents or to one another.
	grow to survive;plants and animals change as they grow, have varied life cycles, and eventually die; and		
	d) offspring of plants and animals are similar but not identical to their parents or to one another.		
K.8	The student will investigate and understand that shadows occur when light is blocked by an object. Key concepts include a) shadows occur in nature when sunlight is blocked by	K.8	The student will investigate and understand that light influences temperature on Earth's surfaces and can cause shadows. Key ideas include a) the sun provides light and warms Earth's surface; b) shadows can be produced when surlight or artificial light is
	b) shadows can be produced by blocking artificial light sources.		 c) shadows can be produced when sumght of artificial right is blocked by an object; and c) objects in shadows and objects in sunlight have different temperatures.
K.9	 The student will investigate and understand that there are simple repeating patterns in his/her daily life. Key concepts include a) weather observations; b) the shapes and forms of many common natural objects including seeds, cones, and leaves; and c) animal and plant growth. 	K.9	The student will investigate and understand that there are patterns in nature. Key patterns includea) daily weather;b) seasonal changes; andc) day and night.
K.10	 The student will investigate and understand that change occurs over time and rates may be fast or slow. Key concepts include a) natural and human-made things may change over time; and b) changes can be observed and measured. 	K.10	 The student will investigate and understand that change occurs over time. Key ideas include a) natural and human-made things change over time; b) living and nonliving things change over time; c) changes can be observed and measured; and d) changes may be fast or slow.
K.11	The student will investigate and understand that materials can be reused, recycled, and conserved. Key concepts include a) materials and objects can be used over and over again; b) everyday materials can be recycled; and	K.11	The student will investigate and understand that humans use resources. Key ideas includea) some materials and objects can be used over and over again;b) materials can be recycled; and

2010	2018
c) water and energy conservation at home and in school helps ensure resources are available for future use.	c) choices we make impact the air, water, land and living things.

First Grade Cross Walk

2018 Theme: How I interact with my world

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- K-6 themes have been built into the standards to allow for a more cohesive approach to the instruction of science concepts.
- The sections of Life Processes and Living Systems have been combined into one section, Living Systems and Processes.
- The sections of Interrelationships in Earth/Space Systems and Earth Patterns, Cycles, and Change have been combined into one section, Earth and Space Systems.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to First Grade science:

- The development of matter builds from concrete to more abstract K-5. The physical properties of materials are emphasized in first grade. The interaction of materials with water was moved to grade three due to the abstract nature of the concept.
- The ability of materials to transmit light was added to the physical properties of matter in order to align with national standards.
- Natural resources was restructured to reflect the responsible use of resources (1.8).

	2010		2018
1.1	The student will demonstrate an understanding of scientific	1.1	The student will demonstrate an understanding of scientific and
	reasoning, logic, and the nature of science by planning and		engineering practices by
	conducting investigations in which		a) asking questions and defining problems
	a) the senses are used to observe differences in physical		 ask questions and make predictions based on
	properties;		observations

2010	2018
 b) observations are made from multiple positions to achieve a variety of perspectives and are repeated to ensure accuracy; c) objects or events are classified and arranged according to characteristics or properties; d) simple tools are used to enhance observations; e) length, mass, volume, and temperature are measured using nonstandard units; f) inferences are made and conclusions are drawn about familiar objects and events; g) a question is developed from one or more observations; h) predictions are made based on patterns of observations; i) observations and data are recorded, analyzed, and communicated orally and with simple graphs, pictures, written statements, and numbers; and j) simple investigations and experiments are conducted to answer questions. 	 identify a simple problem that can be solved through the development of a new tool or improved object b) planning and carrying out investigations with guidance, conduct investigations to produce data identify characteristics and properties of objects by observations use tools to measure relative length, weight, volume, and temperature of common objects c) interpreting, analyzing, and evaluating data use and share pictures, drawings, and/or writings of observations describe patterns and relationships classify and arrange objects based on a single physical characteristic or property organize and represent various forms of data using tables, picture graphs, and object graphs read and interpret data displayed in tables, picture graphs, and object graphs, using the vocabulary <i>more</i>, <i>less, fewer, greater than, less than, and equal to</i> d) constructing and critiquing conclusions and explanations make simple conclusions based on data or observations use physical models use physical models to demonstrate simple phenomena and natural processes f) obtaining, evaluating, and communicating information communicate observations and data using simple graphs, pictures, drawings, numbers, speech and/or writing
1.2 The student will investigate and understand that moving objects exhibit different kinds of motion. Key concepts include	1.2 The student will investigate and understand that objects can move in different ways. Key ideas includea) objects may have straight, circular, spinning, and back-and-forth motions; and

	2010	2018
	a) objects may have straight, circular, and back-and-forth motions;	b) objects may vibrate and produce sound.
	b) objects may vibrate and produce sound; and	
	c) pushes or pulls can change the movement of an object.	
		 1.3 The student will investigate and understand that objects are made from materials that can be described by their physical properties. Key ideas include a) objects are made of one or more materials with different physical properties and can be used for a variety of purposes; b) when a material is changed in size most physical properties remain the same; and c) the type and amount of material determine how much light can pass through an object.
1.3	 The student will investigate and understand how different common materials interact with water. Key concepts include a) some liquids will separate when mixed with water, but others will not; b) some solids will dissolve in water, but others will not; and c) some substances will dissolve more readily in hot water than in cold water. 	
1.4	 The student will investigate and understand that plants have basic life needs and functional parts and can be classified according to certain characteristics. Key concepts include a) plants need nutrients, air, water, light, and a place to grow; b) basic parts of plants; and c) plants can be classified based on a variety of characteristics. 	 1.4 The student will investigate and understand that plants have basic life needs and functional parts that allow them to survive. Key ideas include a) plants need nutrients, air, water, light, and a place to grow; b) structures of plants perform specific functions; and c) plants can be classified based on a variety of characteristics.

	2010		2018
1.5	 The student will investigate and understand that animals, including humans, have basic needs and certain distinguishing characteristics. Key concepts include a) basic needs include adequate air, food, water, shelter, and space (habitat); b) animals, including humans, have many different physical characteristics; and c) animals can be classified according to a variety of characteristics. 	1.5	 The student will investigate and understand that animals, including humans, have basic life needs that allow them to survive. Key ideas include a) animals need air, food, water, shelter, and space (habitat); b) animals have different physical characteristics that perform specific functions; and c) animals can be classified based on a variety of characteristics.
1.6	 The student will investigate and understand the basic relationships between the sun and Earth. Key concepts include a) the sun is the source of energy and light that warms the land, air, and water; and b) the sun's relative position in the morning is east and in the late afternoon is west. 	1.6	 The student will investigate and understand that there is a relationship between the sun and Earth. Key ideas include a) the sun is the source of energy and light that warms the Earth's land, air, and water; and b) the sun's relative position changes in the Earth's sky throughout the day.
1.7	 The student will investigate and understand weather and seasonal changes. Key concepts include a) changes in temperature, light, and precipitation affect plants and animals, including humans; b) there are relationships between daily and seasonal changes; and c) changes in temperature, light, and precipitation can be observed and recorded over time. 	1.7	 The student will investigate and understand that there are weather and seasonal changes. Key ideas include a) changes in temperature, light, and precipitation occur over time; b) there are relationships between daily weather and the season; and c) changes in temperature, light, and precipitation affect plants and animals, including humans.
1.8	 The student will investigate and understand that natural resources are limited. Key concepts include a) identification of natural resources; b) factors that affect air and water quality; and c) recycling, reusing, and reducing consumption of natural resources. 	1.8	 The student will investigate and understand that natural resources can be used responsibly. Key ideas include a) most natural resources are limited; b) human actions can affect the availability of natural resources; and c) reducing, reusing, and recycling are ways to conserve natural resources. d) reducing, reusing, and recycling are ways to conserve natural resources.

Second Grade Cross Walk

2018 Theme: Change occurs all around us

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- K-6 themes have been built into the standards to allow for a more cohesive approach to the instruction of science concepts.
- The sections of Life Processes and Living Systems have been combined into one section, Living Systems and Processes.
- The sections of Interrelationships in Earth/Space Systems and Earth Patterns, Cycles, and Change have been combined into one section, Earth and Space Systems.
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Summary of changes specific to Second Grade science:

- The concept of force continues to develop as students learn that forces can be direct (push or a pull) or can occur over a distance (magnetism and gravity). The term force is introduced in second grade.
- Emphasis is placed on change to include that changes can happen quickly or slowly. This concept applied to both living systems and Earth processes.
- Fossils was moved to third grade to support adaptations.
- Plants are recognized explicitly as a natural resource.
- The concept of matter is explicitly defined in 2.3.

	2010		2018
2.1	The student will demonstrate an understanding of scientific	2.1	The student will demonstrate an understanding of scientific and
	reasoning, logic, and the nature of science by planning and		engineering practices by
	conducting investigations in which		a) asking questions and defining problems
	a) observations and predictions are made and questions		• ask questions that can be investigated
	are formed;		-

	2010	2018
b)	observations are differentiated from personal interpretation;	 make predictions based on observations and prior experiences
c)	observations are repeated to ensure accuracy;	• identify a simple problem that can be solved through the
d)	two or more characteristics or properties are used to	development of a new tool or improved object
	classify items;	b) planning and carrying out investigations
e)	length, volume, mass, and temperature are measured in metric units and standard English units using the proper	• with guidance, plan and conduct simple investigations to produce data
6	tools;	• use appropriate tools to measure length, weight, and
(1) g)	conditions that influence a change are identified and	temperature of common objects using U.S. Customary units
b)	data are collected and recorded, and har graphs are	 measure time intervals using proper tools
1)	constructed using numbered axes:	c) interpreting, analyzing, and evaluating data
i)	data are analyzed, and unexpected or unusual	• organize and represent data in pictographs and bar graphs
1)	quantitative data are recognized;	 read and interpret data represented in pictographs and bar graphs
J)	conclusions are drawn;	d) constructing and critiquing conclusions and explanations
k)	observations and data are communicated;	• make simple conclusions based on data or observations
1)	simple physical models are designed and constructed to	• distinguish between opinion and evidence
	clarify explanations and snow relationships; and	• recognize unusual or unexpected results
m	current applications are used to reinforce science	e) developing and using models
	concepts.	• use models to demonstrate simple phenomena and natural processes
		f) obtaining, evaluating, and communicating information
		• communicate observations and data using simple graphs.
		drawings, numbers, speech, and/or writing
2.2 Th	he student will investigate and understand that natural and	2.2 The student will investigate and understand that different types
art	tificial magnets have certain characteristics and attract	of forces may cause an object's motion to change. Key ideas
sp	ecific types of metals. Key concepts include	include
a)	magnetism, iron, magnetic/nonmagnetic, poles,	a) forces from direct contact can cause an object to move;
	attract/repel; and	b) some forces, including gravity and magnetism, can cause
b)	important applications of magnetism.	objects to move from a distance; and
		c) forces have applications in our lives.

2010		2018	
2.3	 The student will investigate and understand basic properties of solids, liquids, and gases. Key concepts include a) identification of distinguishing characteristics of solids, liquids, and gases; b) measurement of the mass and volume of solids and liquids; and c) changes in phases of matter with the addition or removal of energy. 	2.3	 The student will investigate and understand that matter can exist in different phases. Key ideas include a) matter has mass and takes up space; b) solids, liquids, and gases have different characteristics; and c) heating and cooling can change the phases of matter.
2.4	The student will investigate and understand that plants and animals undergo a series of orderly changes as they mature and grow. Key concepts include a) animal life cycles; and b) plant life cycles.	2.4	The student will investigate and understand that plants and animals undergo a series of orderly changes as they grow and develop. Key ideas include a) animals have life cycles; and b) plants have life cycles.
2.5	 The student will investigate and understand that living things are part of a system. Key concepts include a) living organisms are interdependent with their living and nonliving surroundings; b) an animal's habitat includes adequate food, water, shelter or cover, and space; c) habitats change over time due to many influences; and d) fossils provide information about living systems that were on Earth years ago. 	2.5	 The student will investigate and understand that living things are part of a system. Key ideas include a) plants and animals are interdependent with their living and nonliving surroundings; b) an animal's habitat provides all of its basic needs; and c) habitats change over time due to many influences.
2.6	 The student will investigate and understand basic types, changes, and patterns of weather. Key concepts include a) identification of common storms and other weather phenomena; b) the uses and importance of measuring, recording, and interpreting weather data; and c) the uses and importance of tracking weather data over time. 	2.6	 The student will investigate and understand that there are different types of weather on Earth. Key ideas include a) different types of weather have specific characteristics; b) measuring, recording, and interpreting weather data allows for identification of weather patterns; and c) tracking weather allows us to prepare for the weather and storms
2.7	The student will investigate and understand that weather and seasonal changes affect plants, animals, and their surroundings. Key concepts include	2.7	The student will investigate and understand that weather patterns and seasonal changes affect plants, animals, and their surroundings. Key ideas include

2010	2018
a) effects of weather and seasonal changes on the growth and behavior of living things; andb) weathering and erosion of land surfaces.	a) weather and seasonal changes affect the growth and behavior of living things;b) wind and weather can change the land; andc) changes can happen quickly or slowly over time.
 2.8 The student will investigate and understand that plants produce oxygen and food, are a source of useful products, and provide benefits in nature. Key concepts include a) important plant products are identified and classified; b) the availability of plant products affects the development of a geographic area; c) plants provide oxygen, homes, and food for many animals; and d) plants can help reduce erosion. 	 2.8 The student will investigate and understand that plants are important natural resources. Key ideas include a) the availability of plant products affects the development of a geographic area; b) plants provide oxygen, homes, and food for many animals; and c) plants can help reduce the impact of wind and water.

Third Grade Cross Walk

2018 Theme: Interactions in our world

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- K-6 themes have been built into the standards to allow for a more cohesive approach to the instruction of science concepts.
- The sections of Life Processes and Living Systems have been combined into one section, Living Systems and Processes.
- The sections of Interrelationships in Earth/Space Systems and Earth Patterns, Cycles, and Change have been combined into one section, Earth and Space Systems.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Third Grade science:

- The number of standards and concepts in third grade science was reduced to support the instruction of concepts at a greater level of depth.
- Force, net force, and motion are explicitly tied into simple machines.
- Concept of net force was introduced in order to align with expectations in the national science standards.
- The focus of the third grade matter strand is on the interactions of water with other materials. This standard, previously a first grade standard, was moved to third grade due to the abstract nature of the concept.
- Fossils were moved from second to third grade in order to support animal adaptations as a response to the environment.
- Living Systems and Processes standards were revised to emphasize population adaptations and the interrelationships of organisms in different ecosystems.
- 2010 standards 3.5 and 3.6 were combined to support components of the ecosystem and the relationships of organisms within the ecosystem.

- 2018 standards 3.5 and 3.6 were worded more generally to highlight a more systems-based approach to the content (ecosystems & soil).
- Standard 3.8 was eliminated due to abstract nature of the content (role of sun, moon and Earth in causing cycles and phases). The concepts were moved to sixth grade.
- Sources of renewable and nonrenewable energy standards, 2010 standard 3.11 were moved to fifth grade to support theme of Transformations in Matter and Energy.

2010	2018
 3.1 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 and are repeated to ensure accuracy; b) predictions are formulated using a variety of sources of information; c) objects with similar characteristics or properties are classified into at least two sets and two subsets; d) natural events are sequenced chronologically; e) length, volume, mass, and temperature are estimated and measured in metric and standard English units using proper tools and techniques; f) time is measured to the nearest minute using proper tools and techniques; g) questions are developed to formulate hypotheses; h) data are gathered, charted, graphed, and analyzed; i) unexpected or unusual quantitative data are recognized; j) inferences are made and conclusions are drawn; k) data are communicated; l) models are designed and built; and m) current applications are used to reinforce science concepts. 	 The student will demonstrate an understanding of scientific and engineering practices by a) asking questions and defining problems ask questions that can be investigated and predict reasonable outcomes ask questions about what would happen if a variable is changed define a simple design problem that can be solved through the development of an object, tool, process, or system b) planning and carrying out investigations with guidance, plan and conduct investigations use appropriate methods and/or tools for collecting data estimate length, mass, volume, and temperature measure length, mass, volume, and temperature in metric and U.S. Customary units using proper tools measure elapsed time use tools and/or materials to design and/or build a device that solves a specific problem c) interpreting, analyzing, and evaluating data organize and represent data in pictographs or bar graphs read, interpret, and analyze data represented in pictographs and bar graphs analyze data from tests of an object or tool to determine if it works as intended

	2010		2018
			 use evidence (measurements, observations, patterns) to construct or support an explanation generate and/or compare multiple solutions to a problem describe how scientific ideas apply to design solutions e) developing and using models use models to demonstrate simple phenomena and natural processes develop a model (e.g., diagram or simple physical prototype) to illustrate a proposed object, tool, or process f) obtaining, evaluating, and communicating information read and comprehend reading-level appropriate texts and/or other reliable media communicate scientific information, design ideas, and/or solutions with others.
 3.2 The student v machines and a) purpose a b) types of s c) compound d) examples the school 	will investigate and understand simple d their uses. Key concepts include and function of simple machines; simple machines; d machines; and of simple and compound machines found in al, home, and work environments.	3.2	 The student will investigate and understand that the direction and size of force affects the motion of an object. Key ideas include a) multiple forces may act on an object; b) the net force on an object determines how an object moves; c) simple machines increase or change the direction of a force; and d) simple and compound machines have many applications.
		3.3	The student will investigate and understand how materials interact with water. Key ideas includea) solids and liquids mix with water in different ways; andb) many solids dissolve more easily in hot water than in cold water.
3.3 The student v made of mate properties. K a) objects an	will investigate and understand that objects are erials that can be described by their physical ey concepts include re made of one or more materials;		

	2010		2018
	b) physical properties remain the same as the material is		
	changed in visible size; and		
2.4	c) visible physical changes are identified.	2.4	
3.4	I he student will investigate and understand that	3.4	The student will investigate and understand that adaptations
	to the anying mont. Vay concerts include		allow organisms to satisfy file needs and respond to the
	a) here the information of the i		environment. Key ideas include
	a) behavioral adaptations, and b) physical adaptations		a) populations may adapt over time, b) adaptations may be behavioral or physical; and
	b) physical adaptations.		b) adaptations may be benavioral of physical, and a) fossils provide evidence shout the types of organisms that
			lived long ago as well as the nature of their environments.
3.5	The student will investigate and understand relationships	3.5	The student will investigate and understand that aquatic and
	among organisms in aquatic and terrestrial food chains.		terrestrial ecosystems support a diversity of organisms. Key
	Key concepts include		ideas include
	a) producer, consumer, decomposer;		a) ecosystems are made of living and nonliving components of
	b) herbivore, carnivore, omnivore; and		the environment; and
	c) predator and prey.		b) relationships exist among organisms in an ecosystem.
3.6	The student will investigate and understand that		
	ecosystems support a diversity of plants and animals that		
	share limited resources. Key concepts include		
	a) aquatic ecosystems;		
	b) terrestrial ecosystems;		
	c) populations and communities; and		
	d) the human role in conserving limited resources.		
3.7	The student will investigate and understand the major	3.6	The student will investigate and understand that soil is important
	components of soil, its origin, and its importance to plants		in ecosystems. Key ideas include
	and animals including humans. Key concepts include		a) soil, with its different components, is important to organisms;
	a) soil provides the support and nutrients necessary for		and
	plant growth;		b) soil provides support and nutrients necessary for plant
	b) topsoil is a natural product of subsoil and bedrock;		growth.
	c) rock, clay, silt, sand, and humus are components of 1		
	solls; and		
2.0	a) soll is a natural resource and should be conserved.		
3.8	I he student will investigate and understand basic patterns		
	and cycles occurring in nature. Key concepts include		

	2010	2018
	 a) patterns of natural events such as day and night, seasonal changes, simple phases of the moon, and tides; b) animal life cycles; and c) plant life cycles. 	
3.9	 The student will investigate and understand the water cycle and its relationship to life on Earth. Key concepts include a) there are many sources of water on Earth; b) the energy from the sun drives the water cycle; c) the water cycle involves several processes; d) water is essential for living things; and e) water on Earth is limited and needs to be conserved. 	 3.7 The student will investigate and understand that there is a water cycle and water is important to life on Earth. Key ideas include a) there are many reservoirs of water on Earth; b) the energy from the sun drives the water cycle; and c) the water cycle involves specific processes.
3.10	 The student will investigate and understand that natural events and human influences can affect the survival of species. Key concepts include a) the interdependency of plants and animals; b) the effects of human activity on the quality of air, water, and habitat; c) the effects of fire, flood, disease, and erosion on organisms; and d) conservation and resource renewal. 	 3.8 The student will investigate and understand that natural events and humans influence ecosystems. Key ideas include a) human activity affects the quality of air, water, and habitats; b) water is limited and needs to be conserved; c) fire, flood, disease, and erosion affect ecosystems; and d) soil is a natural resource and should be conserved.
3.11	 The student will investigate and understand different sources of energy. Key concepts include a) energy from the sun; b) sources of renewable energy; and c) sources of nonrenewable energy. 	

Fourth Grade Cross Walk

2018 Theme: Our place in the solar system

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- K-6 themes have been built into the standards to allow for a more cohesive approach to the instruction of science concepts.
- The sections of Life Processes and Living Systems have been combined into one section, Living Systems and Processes.
- The sections of Interrelationships in Earth/Space Systems and Earth Patterns, Cycles, and Change have been combined into one section, Earth and Space Systems.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Fourth Grade science:

- There was significant movement of content between fourth and fifth grade to allow for more concrete content in fourth grade and more abstract content in 5th grade. The rationale is twofold; the first is to allow for additional time for maturation of cognitive ability in students, and the second is to group content around a theme that will allow for conceptual connections within each academic year. This arrangement also allows for more interdisciplinary connections with Social Studies.
- Content from previous life processes and living system strand content in 5th grade, including classification, has been moved to 4th grade to make more robust standards that align to theme.
- Ocean environment has been added to fourth grade in order to align to theme and the emphasis on the world.
- The expectation that students learn the parts of the cell and their corresponding functions was removed from the elementary standards due to the abstract nature of these concepts.

	2010		2018
4.1	The student will demonstrate an understanding of scientific	4.1	The student will demonstrate an understanding of scientific and
	reasoning, logic, and the nature of science by planning and		engineering practices by
	conducting investigations in which		a) asking questions and defining problems

2010	2018
a) distinctions are made among observations, conclusions, inferences, and predictions;	 identify scientific and non-scientific questions develop hypotheses as cause-and-effect relations
b) objects or events are classified and arranged according to characteristics or properties;	 define a simple design problem that can be solved through the development of an object, tool, process, or system
 to characteristics or properties; appropriate instruments are selected and used to measure length, mass, volume, and temperature in metric units; appropriate instruments are selected and used to measure elapsed time; predictions and inferences are made, and conclusions are drawn based on data from a variety of sources; independent and dependent variables are identified; constants in an experimental situation are identified; hypotheses are developed as cause and effect relationships; data are collected, recorded, analyzed, and displayed using bar and basic line graphs; numerical data that are contradictory or unusual in experimental results are recognized; data are communicated with simple graphs, pictures, 	 the development of an object, tool, process, or system planning and carrying out investigations identify variables when planning an investigation collaboratively plan and conduct investigations use tools and/or materials to design and/or build a device that solves a specific problem take metric measurements using appropriate tools measure elapsed time c) interpreting, analyzing, and evaluating data organize and represent data in bar graphs and line graphs interpret and analyze data represented in bar graphs and line graphs compare two different representations of the same data (e.g., a set of data displayed on a chart and a graph) analyze data from tests of an object or tool to determine whether it works as intended
 and numbers; models are constructed to clarify explanations, demonstrate relationships, and solve needs; and 	 use evidence (i.e., measurements, observations, patterns) to construct or support explanations and to make inferences
m) current applications are used to reinforce science concepts.	 e) developing and using models develop and/or use models to explain natural phenomena identify limitations of models f) obtaining, evaluating, and communicating information read and comprehend reading-level-appropriate texts and/or other reliable media communicate scientific information, design ideas, and/or solutions with others.
4.2 The student will investigate and understand characteristics and interactions of moving objects. Key concepts include	

	2010	2018
	 a) motion is described by an object's direction and speed; b) changes in motion are related to force and mass; c) friction is a force that opposes motion; and d) moving objects have kinetic energy. 	
4.3	 The student will investigate and understand the characteristics of electricity. Key concepts include a) conductors and insulators; b) basic circuits; c) static electricity; d) the ability of electrical energy to be transformed into light and motion, and to produce heat; e) simple electromagnets and magnetism; and f) historical contributions in understanding electricity. 	
4.4	 The student will investigate and understand basic plant anatomy and life processes. Key concepts include a) the structures of typical plants and the function of each structure; b) processes and structures involved with plant reproduction; c) photosynthesis; and d) adaptations allow plants to satisfy life needs and respond to the environment. 	 4.2 The student will investigate and understand that plants and animals have structures that distinguish them from one another and play vital roles in their ability to survive. Key ideas include a) the survival of plants and animals depends on photosynthesis; b) plants and animals have different structures and processes for obtaining energy; and c) plants and animals have different structures and processes for creating offspring.
4.5	 The student will investigate and understand how plants and animals, including humans, in an ecosystem interact with one another and with the nonliving components in the ecosystem. Key concepts include a) plant and animal adaptations; b) organization of populations, communities, and ecosystems and how they interrelate; c) flow of energy through food webs; d) habitats and niches; e) changes in an organism's niche at various stages in its life cycle; and 	 4.3 The student will investigate and understand that organisms, including humans, interact with one another and with the nonliving components in the ecosystem. Key ideas include a) interrelationships exist in populations, communities, and ecosystems; b) food webs show the flow of energy within an ecosystem; c) changes in an organism's niche and habitat may occur at various stages in its life cycle; and d) classification can be used to identify organisms.

	2010 2018		2018
	f) influences of human activity on ecosystems.		
4.6	 The student will investigate and understand how weather conditions and phenomena occur and can be predicted. Key concepts include e) weather phenomena; f) weather measurements and meteorological tools; and g) use of weather measurements and weather phenomena to make weather predictions. 	4.4	 The student will investigate and understand that weather conditions and phenomena affect ecosystems and can be predicted. Key ideas include a) weather measurements create a record that can be used to make weather predictions; b) common and extreme weather events affect ecosystems; and c) long term seasonal weather trends determine the climate of a region.
4.7	The student will investigate and understand the organization of the solar system. Key concepts includea) the planets in the solar system;b) the order of the planets in the solar system; andc) the relative sizes of the planets.	4.5	 The student will investigate and understand that the planets have characteristics and a specific place in the solar system. Key ideas include a) planets rotate on their axes and revolve around the sun; b) planets have characteristics and a specific order in the solar system; and c) the sizes of the sun and planets can be compared to one another.
4.8	 The student will investigate and understand the relationships among Earth, the moon, and the sun. Key concepts include a) the motions of Earth, the moon, and the sun; b) the causes for Earth's seasons; c) the causes for the phases of the moon; d) the relative size, position, age, and makeup of Earth, the moon, and the sun; and e) historical contributions in understanding the Earth-moon-sun system. 	4.6	 The student will investigate and understand that there are relationships among Earth, the moon, and the sun. Key relationships include a) the motions of Earth, the moon, and the sun; b) the causes for Earth's seasons; c) the causes for the four major phases of the moon and the relationship to the tide cycles; and d) the relative size, position, age and makeup of Earth, the moon, and the sun.
		4.7	The student will investigate and understand that the ocean environment has characteristics. Key characteristics includea) geology of the ocean floor;b) physical properties and movement of ocean water; andc) interaction of organisms in the ocean.
4.9	The student will investigate and understand important Virginia natural resources. Key concepts include	4.8	The student will investigate and understand that Virginia has important natural resources. Key resources include

2010	2018
a) watersheds and water resources;	a) watersheds and water;
b) animals and plants;	b) plants and animals;
c) minerals, rocks, ores, and energy sources; and	c) minerals, rocks, and ores; and
d) forests, soil, and land.	d) forests, soil, and land.

Fifth Grade Cross Walk

2018 Theme: Transforming matter and energy

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- K-6 themes have been built into the standards to allow for a more cohesive approach to the instruction of science concepts.
- The sections of Life Processes and Living Systems have been combined into one section, Living Systems and Processes.
- The sections of Interrelationships in Earth/Space Systems and Earth Patterns, Cycles, and Change have been combined into one section, Earth and Space Systems.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Fifth Grade science:

- There has been significant movement of content between fourth and fifth grade to allow for more concrete content in fourth grade and more abstract content in 5th grade. The rationale is twofold; the first is to allow for additional time for maturation of cognitive ability in students, and the second is to group content around a theme that will allow for conceptual connections within each academic year.
- Emphasis on energy and energy transformations was added to unify concepts of electricity, sound, and light.
- The relationship between force and energy on objects supports vertical development of force concepts throughout the elementary standards.
- The transfer of energy in the form of electricity was moved from fourth grade to fifth grade.
- Atomic structure as well as specific terms describing matter (molecules, elements, compounds) was removed from the elementary science standards due to abstract nature of these concepts.
- Earth and Space Systems strands were revised to reflect the role of energy in Earth change to include the role of energy in plate tectonics, the rock cycle, and other processes that change Earth's surface.
- Standard 5.9 was added to reflect the conservation of matter and energy.
- The expectation that students learn the parts of the cell and their corresponding functions was removed from the elementary standards due to the abstract nature of these concepts.

2010	2018
5.1 The student will demonstrate an understanding of	5.1 The student will demonstrate an understanding of scientific and
scientific reasoning, logic, and the nature of science by	engineering practices by
planning and conducting investigations in which	a) asking questions and defining problems
a) items such as rocks, minerals, and organisms are	 ask testable questions based on observations and predict
identified using various classification keys;	reasonable outcomes based on patterns
b) estimates are made and accurate measurements of	 develop hypotheses as cause-and-effect relationship
length, mass, volume, and temperature are made in	• define design problems that can be solved through the
metric units using proper tools;	development of an object, tool, process, or system
c) estimates are made and accurate measurements of	b) planning and carrying out investigations
d) hypotheses are formed from testable questions:	 collaboratively plan and conduct investigations to produce data
e) independent and dependent variables are identified;	• identify independent variable, dependent variables, and
f) constants in an experimental situation are identified;	constants
g) data are collected, recorded, analyzed, and	 determine data that should be collected to answer a
communicated using proper graphical representations	testable question
and metric measurements;	• take metric measurements using appropriate tools
n) predictions are made using patterns from data	• use tools and/or materials to design and/or build a device
i) inferences are made and conclusions are drawn:	that solves a specific problem
i) models are constructed to clarify explanations	c) interpreting, analyzing, and evaluating data
demonstrate relationships, and solve needs: and	 represent and analyze data using tables and graphs
k) current applications are used to reinforce science	 organize simple data sets to reveal patterns that suggest
concepts.	• compare and contrast data collected by different groups
	and discuss similarities and differences in their findings
	 use data to evaluate and refine design solutions
	d) constructing and critiquing conclusions and explanations
	construct and/or support arguments with evidence_data
	and/or a model
	 describe how scientific ideas apply to design solutions
	• generate and compare multiple solutions to problems
	based on how well they meet the criteria and constraints
	e) developing and using models

2010	2018
	 develop models using an analogy, example, or abstract representation to describe a scientific principle or design solution identify limitations of models f) obtaining, evaluating, and communicating information read and comprehend reading-level-appropriate texts and/or other reliable media communicate scientific information, design ideas, and/or solutions with others
	 5.2 The student will investigate and understand that energy can take many forms. Key ideas include a) energy is the ability to do work or to cause change; b) there are many different forms of energy; c) energy can be transformed; and d) energy is conserved.
	 5.3 The student will investigate and understand that there is a relationship between force and energy of moving objects. Key ideas include a) moving objects have kinetic energy; b) motion is described by an object's direction and speed; c) changes in motion are related to net force and mass; d) when objects collide, the contact forces transfer energy and can change objects' motion; and e) friction is a force that opposes motion.
	 5.4 The student will investigate and understand that electricity is transmitted and used in daily life. Key ideas include a) electricity flows easily through conductors but not insulators; b) electricity flows through closed circuits; c) static electricity can be generated by rubbing certain materials together; d) electrical energy can be transformed into radiant, mechanical, and thermal energy; and e) a current flowing through a wire creates a magnetic field.

	2010		2018
5.2	 The student will investigate and understand how sound is created and transmitted, and how it is used. Key concepts include a) compression waves; b) vibration, compression, wavelength, frequency, amplitude; c) the ability of different media (solids, liquids, and gases) to transmit sound; and d) uses and applications of sound waves. 	5.5	 The student will investigate and understand that sound can be produced and transmitted. Key ideas include a) sound is produced when an object or substance vibrates; b) sound is the transfer of energy; c) different media transmit sound differently; and d) sound waves have many uses and applications.
5.3	 The student will investigate and understand basic characteristics of visible light and how it behaves. Key concepts include g) transverse waves; h) the visible spectrum; i) opaque, transparent, and translucent; j) reflection of light from reflective surfaces; and k) refraction of light through water and prisms. 	5.6	 The student will investigate and understand that visible light has certain characteristics and behaves in predictable ways. Key ideas include a) visible light is radiant energy that moves in transverse waves; b) the visible spectrum includes light with different wavelengths; c) matter influences the path of light; and d) radiant energy can be transformed into thermal, mechanical, and electrical energy.
5.4	 The student will investigate and understand that matter is anything that has mass and takes up space; and occurs as a solid, liquid, or gas. Key concepts include a) distinguishing properties of each phase of matter; b) the effect of temperature on the phases of matter; c) atoms and elements; d) molecules and compounds; and e) mixtures including solutions. 	5.7	 The student will investigate and understand that matter has properties and interactions. Key ideas include a) matter is composed of atoms; b) substances can be mixed together without changes in their physical properties; and c) energy has an effect on the phases of matter.
5.5	The student will investigate and understand that organisms are made of one or more cells and have distinguishing characteristics that play a vital role in the organism's ability to survive and thrive in its environment. Key concepts include a) basic cell structures and functions;		

2010		2018	
b) c)	classification of organisms using physical characteristics, body structures, and behavior of the organism; and traits of organisms that allow them to survive in their environment.		
5.6 The of t a) b) c)	e student will investigate and understand characteristics the ocean environment. Key concepts include geological characteristics; physical characteristics; and ecological characteristics.		
5.7 The sur a) b) c) d) e) f) g)	e student will investigate and understand how Earth's face is constantly changing. Key concepts include identification of rock types; the rock cycle and how transformations between rocks occur; Earth history and fossil evidence; the basic structure of Earth's interior; changes in Earth's crust due to plate tectonics; weathering, erosion, and deposition; and human impact.	5.8	 The student will investigate and understand that Earth constantly changes. Key ideas include a) Earth's internal energy causes movement of material within the Earth; b) plate tectonics describe movement of the crust; c) the rock cycle models the transformation of rocks; d) processes such as weathering, erosion, and deposition change the surface of the Earth; and e) fossils and geologic patterns provide evidence of Earth's change.
5/		5.9	 The student will investigate and understand that the conservation of energy resources is important. Key ideas include a) some sources of energy are considered renewable and others are not; b) individuals and communities have means of conserving both energy and matter; and c) advances in technology improve the ability to transfer and transform energy.

Sixth Grade Cross Walk

2018 Theme: Our world, our responsibility

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- K-6 themes have been built into the standards to allow for a more cohesive approach to the instruction of science concepts.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Sixth Grade science:

- Strand names were eliminated from the sixth grade standards.
- Standards were reorganized to start at the level of solar system. The concepts in the solar system were reorganized in order to form two separate standards; one standard that pertains to the organization and components of the solar system and the second standard that deals solely with the relationship between the Earth, Moon, and Sun.
- Sixth grade is now the first time students are exposed to the structure of the atom. Terms associated with matter (element, compound, molecule) were removed from the elementary curriculum.
- Standards 6.2 and 6.3 were combined to create one cohesive standard that reflects energy and energy transformations.

2010		2018		
6.1	The student will demonstrate an understanding of	6.1	The student will demonstrate an understanding of scientific and	
	scientific reasoning, logic, and the nature of science by		engineering practices by	
	planning and conducting investigations in which		a) asking questions and defining problems	
	a) observations are made involving fine discrimination		• ask questions to determine relationships between	
	between similar objects and organisms;		independent and dependent variables	
	b) precise and approximate measurements are recorded;		• develop hypotheses and identify independent and	
	c) scale models are used to estimate distance, volume,		dependent variables	
	and quantity;		 offer simple solutions to design problems 	

2010	2018	
d) hypotheses are stated in ways that identify the	b) planning and carrying out investigations	
independent and dependent variables;	• independently and collaboratively plan and conduct	
e) a method is devised to test the validity of predictions	observational and experimental investigations; identify	
and inferences;	variables, constants, and controls where appropriate,	
f) one variable is manipulated over time, using many	including the safe use of chemicals and equipment	
repeated trials;	• evaluate the accuracy of various methods for collecting	
g) data are collected, recorded, analyzed, and reported	data	
using metric measurements and tools;	• take metric measurements using appropriate tools	
h) data are analyzed and communicated through	• use tools and/materials to design and/or build a device to	
graphical representation;	solve a specific problem	
1) models and simulations are designed and used to	c) interpreting, analyzing, and evaluating data	
illustrate and explain phenomena and systems; and	• organize data sets to reveal patterns that suggest	
1) current applications are used to reinforce science	relationships	
concepts.	• construct, analyze, and interpret graphical displays of data	
	• compare and contrast data collected by different groups	
	and discuss similarities and differences in findings	
	• use data to evaluate and refine design solutions	
	d) constructing and critiquing conclusions and explanations	
	• construct explanations that include qualitative or	
	quantitative relationships between variables	
	• construct scientific explanations based on valid and	
	reliable evidence obtained from sources (including the	
	students' own investigations)	
	• generate and compare multiple solutions to problems	
	o) developing and using models	
	e) developing and using models	
	• use develop and revise models to predict and explain	
	• use, develop, and revise models to predict and explain	
	evaluate limitations of models	
	f) obtaining evaluating and communicating information	
	 read scientific texts including those adapted for classroom 	
	use to obtain scientific and/or technical information	
	 f) obtaining, evaluating, and communicating information read scientific texts, including those adapted for classroom use, to obtain scientific and/or technical information 	

2010	2018	
6.8 The student will investigate and understand the	 gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning 6.2 The student will investigate and understand that the solar system 	
 organization of the solar system and the interactions among the various bodies that comprise it. Key concepts include a) the sun, moon, Earth, other planets and their moons, dwarf planets, meteors, asteroids, and comets; b) relative size of and distance between planets; c) the role of gravity; d) revolution and rotation; e) the mechanics of day and night and the phases of the moon; f) the unique properties of Earth as a planet; g) the relationship of Earth's tilt and the seasons; h) the cause of tides; and i) the history and technology of space exploration. 	 b) planets have different sizes and orbit at different distances from the sun; c) gravity contributes to orbital motion; and d) the understanding of the solar system has developed over time. 	
	 6.3 The student will investigate and understand that there is a relationship between the sun, Earth, and the moon. Key ideas include a) Earth has unique properties; b) the rotation of Earth in relationship to the sun causes day and night; c) the movement of Earth and the moon in relationship to the sun causes phases of the moon; d) Earth's tilt as it revolves around the sun causes the seasons; and e) the relationship between Earth and the moon is the primary cause of tides. 	

2010		2018		
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. 	 6.4 The student will investigate and understand that there are basic sources of energy and that energy can be transformed. Key ideas include a) the sun is important in the formation of most energy sources on Earth; b) Earth's energy budget relates to living systems and Earth's processes; c) radiation, conduction, and convection distribute energy; and d) energy transformations are important in energy usage. 		
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. 			
6.4	 The student will investigate and understand that all matter is made up of atoms. Key concepts include a) atoms consist of particles, including electrons, protons, and neutrons; b) atoms of a particular element are alike but are different from atoms of other elements; c) elements may be represented by chemical symbols; d) two or more atoms interact to form new substances, which are held together by electrical forces (bonds); e) compounds may be represented by chemical formulas; f) chemical equations can be used to model chemical changes; and 	 6.5 The student will investigate and understand that all matter is composed of atoms. Key ideas include a) atoms consist of particles, including electrons, protons, and neutrons; b) atoms of a particular element are similar but differ from atoms of other elements; c) elements may be represented by chemical symbols; d) two or more atoms interact to form new substances, which are held together by electrical forces (bonds); e) compounds may be represented by chemical formulas; f) chemical equations can be used to model chemical changes; 		

2010	2018		
g) a limited number of elements comprise the largest portion of the solid Earth, living matter, the oceans, and the atmosphere.	g) a few elements comprise the largest portion of the solid Earth, living matter, the 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 a) water as the universal solvent; b) the properties of water in all three phases; c) the action of water in physical and chemical weathering; d) the ability of large bodies of water to store thermal energy and moderate climate; e) the importance of water for agriculture, power generation, and public health; and f) the importance of protecting and maintaining water resources. 	 6.6 The student will investigate and understand that water has unique physical properties and has a role in the natural and human-made environment. Key ideas include a) water is referred to as the universal solvent; b) water has specific properties; c) thermal energy has a role in phase changes; d) water has a role in weathering; e) large bodies of water moderate climate; and f) water is important for agriculture, power generation, and public health. 		
 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. 	 6.7 The student will investigate and understand that air has properties and that Earth's atmosphere has structure and is dynamic. Key ideas include a) air is a mixture of gaseous elements and compounds; b) the atmosphere has physical characteristics; c) properties of the atmosphere change with altitude; d) there is a relationship between air movement, thermal energy, and weather conditions; e) atmospheric measures are used to predict weather conditions; and f) weather maps give basic information about fronts, systems, and weather measurements. 		
6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include	6.8 The student will investigate and understand that land and water have roles in watershed systems. Key ideas includea) a watershed is composed of the land that drains into a body of water;		

2018		
b) Virginia is composed of multiple watershed systems which have specific features;		
c) the Chesapeake Bay is an estuary that has many important functions; and		
 6.9 The student will investigate and understand that humans impact the environment and individuals can influence public policy decisions related to energy and the environment. Key ideas include a) natural resources are important to protect and maintain; b) renewable and nonrenewable resources can be managed; c) major health and safety issues are associated with air and water quality; d) major health and safety issues are related to different forms of energy; e) preventive measures can protect land-use and reduce environmental hazards; and 		

Life Science Cross Walk

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Life Science:

- Cell transfer (osmosis and diffusion) was added to standard LS.2.
- Classification of organisms was built into LS.3 to tie classification into the structural organization of living things.
- Unicellular and multicellular organisms was added to LS.3.
- Cellular respiration as a process of energy transfer was added to LS.4. The intent of this addition is to include cellular respiration as an essential chemical process but does not include specifics on the cellular respiration process.
- The 2010 standards LS.7 and LS.8 were combined into LS.6 to emphasize both interactions and interdependence between and among populations within biological communities.
- The emphasis has shifted from plants and animals to include all organisms.
- Life Science is now the first time that students encounter cells and organelles.
- Specific phyla were removed from LS.3 (old LS.4) to support the teaching of patterns rather than the teaching of vocabulary.
- Meiosis was added explicitly to LS.10. The intent of this addition is to include the importance of the process in trait transfer and genetic variability, but it does not include the specific steps of meiosis.

2010		2018	
LS.1	The student will demonstrate an understanding of scientific	LS.1	The student will demonstrate an understanding of scientific and
	reasoning, logic, and the nature of science by planning and		engineering practices by
	conducting investigations in which		a) asking questions and defining problems
	a) data are organized into tables showing repeated trials		• ask questions and develop hypotheses to determine
	and means;		relationships between independent and dependent
			variables
2010	2018		
--	--		
b) a classification system is developed based on multiple	 offer simple solutions to design problems 		
attributes;	b) planning and carrying out investigations		
c) triple beam and electronic balances, thermometers,	• independently and collaboratively plan and conduct		
metric rulers, graduated cylinders, and probeware are	observational and experimental investigations; identify		
used to gather data;	variables, constants, and controls where appropriate and		
d) models and simulations are constructed and used to	include the safe use of chemicals and equipment		
illustrate and explain phenomena;	• evaluate the accuracy of various methods for collecting		
e) sources of experimental error are identified;	data		
constants are identified:	• take metric measurements using appropriate tools and		
a) variables are controlled to test hypotheses and trials	technologies including the use of microscopes		
are repeated.	c) interpreting, analyzing, and evaluating data		
h) data are organized, communicated through graphical	• identify, interpret, and evaluate patterns in data		
representation, interpreted, and used to make	• construct, analyze, and interpret graphical displays of		
predictions;	data		
i) patterns are identified in data and are interpreted and	• compare and contrast data confected by differences in their findings		
evaluated; and	and discuss similarities and differences in their midnings		
j) current applications are used to reinforce life science	improve precision and accuracy of data		
concepts.	• use data to evaluate and refine design solutions		
	d) constructing and critiquing conclusions and explanations		
	 construct explanations that include qualitative or 		
	quantitative relationships between variables		
	• construct scientific explanations based on valid and		
	reliable evidence obtained from sources (including the		
	students' own investigations)		
	• differentiate between a scientific hypothesis and theory		
	e) developing and using models		
	• construct and use models and simulations to illustrate,		
	predict, and/or explain observable and unobservable		
	phenomena, life processes, or mechanisms		
	• evaluate limitations of models		
	t) obtaining, evaluating, and communicating information		

2010	2018
	 read scientific texts, including those adapted for classroom use, to obtain scientific and/or technical information gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication construct, use, and/or present an argument supported by empirical evidence and scientific reasoning
 LS.2 The student will investigate and understand that all living things are composed of cells. Key concepts include a) cell structure and organelles; b) similarities and differences between plant and animal cells; c) development of cell theory; and d) cell division. 	 LS.2 The student will investigate and understand that all living things are composed of one or more cells that support life processes, as described by the cell theory. Key ideas include a) the development of the cell theory demonstrates the nature of science; b) cell structure and organelles support life processes; c) similarities and differences between plant and animal cells determine how they support life processes; d) cell division is the mechanism for growth and reproduction; and e) cellular transport (osmosis and diffusion) is important for life processes.
 LS.3 The student will investigate and understand that living things show patterns of cellular organization. Key concepts include a) cells, tissues, organs, and systems; and b) patterns of cellular organization and their relationship to life processes in living things. 	 LS.3 The student will investigate and understand that there are levels of structural organization in living things. Key ideas include a) patterns of cellular organization support life processes; b) unicellular and multicellular organisms have comparative structures; and c) similar characteristics determine the classification of organisms.

	2010		2018
LS.4	 The student will investigate and understand how organisms can be classified. Key concepts include a) the distinguishing characteristics of domains of organisms; b) the distinguishing characteristics of kingdoms of organisms; c) the distinguishing characteristics of major animal phyla and plant divisions; and d) the characteristics that define a species 		
LS.5	 a) the entracteristics that define a species. 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 g) energy transfer between sunlight and chlorophyll; h) transformation of water and carbon dioxide into sugar and oxygen; and i) photosynthesis as the foundation of virtually all food webs. j) the importance of protecting and maintaining water resources. 	LS.4	 The student will investigate and understand that there are chemical processes of energy transfer which are important for life. Key ideas include a) photosynthesis is the foundation of virtually all food webs; and b) photosynthesis and cellular respiration support life processes.
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 a) the carbon, water, and nitrogen cycles; b) interactions resulting in a flow of energy and matter throughout the system; c) complex relationships within terrestrial, freshwater, and marine ecosystems; and d) energy flow in food webs and energy pyramids. 	LS.5	 The student will investigate and understand that biotic and abiotic factors affect an ecosystem. Key ideas include a) matter moves through ecosystems via the carbon, water, and nitrogen cycles; b) energy flow is represented by food webs and energy pyramids; and c) relationships exist among producers, consumers, and decomposers.
LS.7	 The student will investigate and understand that interactions exist among members of a population. Key concepts include a) competition, cooperation, social hierarchy, territorial imperative; and 	LS.6	The student will investigate and understand that populations in a biological community interact and are interdependent. Key ideas includea) relationships exist between predators and prey and these relationships are modeled in food webs;

	2010		2018
	b) influence of behavior on a population.		 b) the availability and use of resources may lead to competition and cooperation; c) symbiotic relationships support the survival of different species; and d) the niche of each organism supports survival.
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. 		
LS.9	 The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem. Key concepts include a) differences between ecosystems and biomes; b) characteristics of land, marine, and freshwater ecosystems; and c) adaptations that enable organisms to survive within a specific ecosystem. 	LS.7	 The student will investigate and understand that adaptations support an organism's survival in an ecosystem. Key ideas include a) biotic and abiotic factors define land, marine, and freshwater ecosystems; and b) physical and behavioral characteristics enable organisms to survive within a specific ecosystem.
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 a) phototropism, hibernation, and dormancy; b) factors that increase or decrease population size; and c) eutrophication, climate changes, and catastrophic disturbances. 	LS.8	 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time. Key ideas include a) organisms respond to daily, seasonal, and long-term changes; b) changes in the environment may increase or decrease population size; and c) large-scale changes such as eutrophication, climate changes, and catastrophic disturbances affect ecosystems.
LS.11	The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include	LS.9	The student will investigate and understand that relationships exist between ecosystem dynamics and human activity. Key ideas include

2010	2018
a) food production and harvest;	a) changes in habitat can disturb populations;
b) change in habitat size, quality, or structure;	b) disruptions in ecosystems can change species competition;
c) change in species competition;	and
d) population disturbances and factors that threaten or	c) variations in biotic and abiotic factors can change
enhance species survival; and	ecosystems.
e) environmental issues.	
LS.12 The student will investigate and understand that organisms	LS.10 The student will investigate and understand that organisms
reproduce and transmit genetic information to new	reproduce and transmit genetic information to new generations.
generations. Key concepts include	Key ideas include
a) the structure and role of DNA;	a) DNA has a role in making proteins that determine organism
b) the function of genes and chromosomes;	traits;
c) genotypes and phenotypes;	b) the role of meiosis is to transfer traits to the next generation;
d) characteristics that can and cannot be inherited;	and
e) genetic engineering and its applications; and	c) Punnett squares are mathematical models used to predict the
f) historical contributions and significance of discoveries	probability of traits in offspring.
related to genetics.	
LS.13 The student will investigate and understand that	LS.11 The student will investigate and understand that populations of
populations of organisms change over time. Key concepts	organisms can change over time. Key ideas include
include	a) mutation, adaptation, natural selection, and extinction
a) the relationships of mutation, adaptation, natural	change populations;
selection, and extinction;	b) the fossil record, genetic information, and anatomical
b) evidence of evolution of different species in the fossil	comparisons provide evidence for evolution; and
record; and	c) environmental factors and genetic variation, influence
c) how environmental influences, as well as genetic	survivability and diversity of organisms.
variation, can lead to diversity of organisms.	

Physical Science Cross Walk

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Physical Science:

- Particle theory of matter was updated to the Kinetic Molecular Theory of Matter (aligns to chemistry).
- Organization of chemistry standards was revised to reflect the atom, properties of processes of matter, and the periodic table. Conservation of matter was moved to support chemical and physical processes.
- To support the concept of energy prior to building specifics in later standards, PS.5 was revised.
- The emphasis on the role of waves in the transfer of energy is in PS.6. Properties of sound waves and terminology is included in the revised standard.
- Electromagnetic energy in included in PS.9. The concepts of temperature and heat have moved to PS.5 and support physical change.
- There is a greater emphasis placed on magnetic fields in PS.9. Students are introduced to the terms magnetic field in fifth grade.

	2010		2018
PS.1	The student will demonstrate an understanding of scientific	PS.1	The student will demonstrate an understanding of scientific
	reasoning, logic, and the nature of science by planning and		and engineering practices by
	conducting investigations in which		a) asking questions and defining problems
	a) chemicals and equipment are used safely;		• ask questions that require empirical evidence to answer
	b) length, mass, volume, density, temperature, weight, and		• develop hypotheses indicating relationships between
	force are accurately measured;		independent and dependent variables
	c) conversions are made among metric units, applying		• offer simple solutions to design problems
	appropriate prefixes;		b) planning and carrying out investigations
			• independently and collaboratively plan and conduct
			observational and experimental investigations; identify

	2010	2018
 d) triple be metric r spring s e) numbers appropri 	eam and electronic balances, thermometers, ulers, graduated cylinders, probeware, and cales are used to gather data; s are expressed in scientific notation where iate:	 variables, constants, and controls where appropriate and include the safe use of chemicals and equipment evaluate the accuracy of various methods for collecting data take metric measurements using appropriate tools and
f) indepen controls g) data tab	dent and dependent variables, constants, s, and repeated trials are identified; les showing the independent and dependent es derived quantities and the number of trials	 take metric measurements using appropriate tools and technologies apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or
h) data tab measure and the	structed and interpreted; les for descriptive statistics showing specific es of central tendency, the range of the data set, number of repeated trials are constructed and	 c) interpreting, analyzing, and evaluating data construct and interpret data tables showing independent and dependent variables, repeated trials, and means construct, analyze, and interpret graphical displays of
i) frequence histogra	cy distributions, scatterplots, line plots, and ms are constructed and interpreted;	 data and consider limitations of data analysis apply mathematical concepts and processes to scientific questions
k) research	nethods are used to investigate practical	• use data to evaluate and refine design solutions to best meet criteria
l) exper written	rimental results are presented in appropriate form;	 d) constructing and critiquing conclusions and explanations construct scientific explanations based on valid and reliable evidence obtained from sources (including the
m) models illustrate	and simulations are constructed and used to e and explain phenomena; and	students' own investigations)
n) current a used.	applications of physical science concepts are	and scientific reasoning
		 generate and compare multiple solutions to problems based on how well they meet the criteria and constraints
		• differentiate between a scientific hypothesis, theory, and law
		e) developing and using models
		construct, develop, and use models and simulations to illustrate and/or explain observable and unobservable phenomena

	2010		2018
			 evaluate limitations of models obtaining, evaluating, and communicating information read scientific texts, including those adapted for classroom use, to determine the central idea and/or obtain scientific and/or technical information gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning
PS.3 The st histori a) the Bo b) the	rudent will investigate and understand the modern and ical models of atomic structure. Key concepts include e contributions of Dalton, Thomson, Rutherford, and ohr in understanding the atom; and e modern model of atomic structure.	PS.2	 The student will investigate and understand that matter is composed of atoms. Key ideas include a) our understanding of atoms has developed over time; b) the periodic table can be used to predict the chemical and physical properties of matter; and c) the kinetic molecular theory is used to predict and explain matter interactions.
PS.2 The st matter a) the b) ele c) so d) ph e) ch f) ch ch	tudent will investigate and understand the nature of r. Key concepts include e particle theory of matter; ements, compounds, mixtures, acids, bases, and salts; lids, liquids, and gases; hysical properties; emical properties; and aracteristics of types of matter based on physical and emical properties.	PS.3	 The student will investigate and understand that matter has properties and is conserved in chemical and physical processes. Key ideas include a) pure substances can be identified based on their chemical and physical properties; b) pure substances can undergo physical and chemical changes that may result in a change of properties; c) compounds form through ionic and covalent bonding; and d) balanced chemical equations model the conservation of matter.
PS.4 The st organi obtain a) sy far	rudent will investigate and understand the ization and use of the periodic table of elements to information. Key concepts include mbols, atomic numbers, atomic mass, chemical milies (groups), and periods;	PS.4	 The student will investigate and understand that the periodic table is a model used to organize elements based on their atomic structure. Key uses include a) symbols, atomic numbers, atomic mass, chemical groups (families), and periods are identified on the periodic table; and

	2010	2018
	b) classification of elements as metals, metalloids, and nonmetals; andc) formation of compounds through ionic and covalent bonding.	b) elements are classified as metals, metalloids, and nonmetals.
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 k) physical changes; l) chemical changes; and m) nuclear reactions.	
PS.6	The student will investigate and understand forms of energy and how energy is transferred and transformed. Key concepts includea) potential and kinetic energy; andb) mechanical, chemical, electrical, thermal, radiant, and nuclear energy.	 PS.5 The student will investigate and understand that energy is conserved. Key ideas include a) energy can be stored in different ways; b) energy is transferred and transformed; and c) energy can be transformed to meet societal needs.
PS.7	 The student will investigate and understand temperature scales, heat, and thermal energy transfer. Key concepts include a) Celsius and Kelvin temperature scales and absolute zero; b) phase change, freezing point, melting point, boiling point, vaporization, and condensation; c) conduction, convection, and radiation; and d) applications of thermal energy transfer. 	
PS.8	 The student will investigate and understand the characteristics of sound waves Key concepts include e) wavelength, frequency, speed, amplitude, rarefaction, and compression; f) resonance; g) the nature of compression waves; and h) technological applications of sound. 	 PS.6 The student will investigate and understand that waves are important in the movement of energy. Key ideas include a) energy may be transferred in the form of longitudinal and transverse waves; b) mechanical waves need a medium to transfer energy; c) waves can interact; and d) energy associated with waves has many applications

	2010		2018
PS.9	 The student will investigate and understand the characteristics of transverse waves. Key concepts include a) wavelength, frequency, speed, amplitude, crest, and trough; b) the wave behavior of light; c) images formed by lenses and mirrors; d) the electromagnetic spectrum; and e) technological applications of light. 	PS.7	 The student will investigate and understand that electromagnetic radiation has characteristics. Key ideas include a) electromagnetic radiation, including visible light, has wave characteristics and behavior; and b) regions of the electromagnetic spectrum have specific characteristics and uses.
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. 	PS.8	The student will investigate and understand that work, force, and motion are related. Key ideas includea) motion can be described using position and time; andb) motion is described by Newton's laws.
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. 	PS.9	 The student will investigate and understand that there are basic principles of electricity and magnetism. Key ideas include a) an imbalance of charge generates static electricity; b) materials have different conductive properties; c) electric circuits transfer energy; d) magnetic fields cause the magnetic effects of certain materials; e) electric current and magnetic fields are related; and f) many technologies use electricity and magnetism.

Biology Cross Walk

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Biology:

- The bullets were reorganized to reflect central idea of each standard stem.
- The relationship between surface area and volume and material transport was removed.
- Protein synthesis was moved to Bio.2 to reflect that it is a biochemical process.
- Bio.4 revised to emphasize bacteria and viruses.
- Human Biology was omitted in standards. Human biology should still be used to support various biological concepts.
- Synthetic biology was added to support genetics strand.

2010	2018
BIO.1 The student will demonstrate an understanding of scientific	BIO.1 The student will demonstrate an understanding of scientific and
reasoning, logic, and the nature of science by planning and	engineering practices by
conducting investigations in which	a) asking questions and defining problems
a) observations of living organisms are recorded in the lab	• ask questions that arise from careful observation of
and in the field;	phenomena and/or organisms, from examining models and
b) hypotheses are formulated based on direct observations	theories, and/or to seek additional information
and information from scientific literature;	• determine which questions can be investigated within the
c) variables are defined and investigations are designed to	scope of the school laboratory or field to determine
test hypotheses;	relationships between independent and dependent variables
d) graphing and arithmetic calculations are used as tools	• generate hypotheses based on research and scientific
in data analysis;	principles

2010	2018
e) conclusions are formed based on recorded quantitative	• make hypotheses that specify what happens to a dependent
and qualitative data;	variable when an independent variable is manipulated
t) sources of error inherent in experimental design are	b) planning and carrying out investigations
identified and discussed;	 individually and collaboratively plan and conduct
g) validity of data is determined;	observational and experimental investigations
h) chemicals and equipment are used in a safe manner;	• plan and conduct investigations or test design solutions in a
i) appropriate technology including computers, graphing	safe and ethical manner including considerations of
calculators, and probeware, is used for gathering and	environmental, social, and personal effects
analyzing data, communicating results, modeling	 determine appropriate sample size and techniques
concepts, and simulating experimental conditions;	• select and use appropriate tools and technology to collect,
j) research utilizes scientific literature;	record, analyze, and evaluate data
k) differentiation is made between a scientific hypothesis,	c) interpreting, analyzing, and evaluating data
theory, and law;	• construct and interpret data tables showing independent and
1) alternative scientific explanations and models are	dependent variables, repeated trials, and means
m) symmetric and analyzed; and	• construct, analyze, and interpret graphical displays of data
iii) current applications of biological concepts are used.	• use data in building and revising models, supporting an
	explanation for phenomena, or testing solutions to problems
	• analyze data using tools, technologies, and/or models to
	make valid and reliable scientific claims or determine an
	optimal design solution
	d) constructing and critiquing conclusions and explanations
	 make quantitative and/or qualitative claims regarding the
	relationship between dependent and independent variables
	 construct and revise explanations based on valid and
	reliable evidence obtained from a variety of sources
	including students' own investigations, models, theories,
	simulations, and peer review
	• apply scientific ideas, principles, and/or evidence to provide
	an explanation of phenomena and design solutions
	 compare and evaluate competing arguments or design
	solutions in light of currently accepted explanations and
	new scientific evidence

2010	2018
	 construct arguments or counterarguments based on data and evidence differentiate between a scientific hypothesis and theory e) developing and using models evaluate the merits and limitations of models develop, revise, and/or use models based on evidence to illustrate or predict relationships develop and/or use models to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems f) obtaining, evaluating, and communicating information compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source communicate scientific and/or technical information about phenomena in multiple formats
 BIO.2 The student will investigate and understand the chemical and biochemical principles essential for life. Key concepts include a) water chemistry and its impact on life processes; b) the structure and function of macromolecules; c) the nature of enzymes; and d) the capture, storage, transformation, and flow of energy through the processes of photosynthesis and respiration 	 BIO.2 The student will investigate and understand that chemical and biochemical processes are essential for life. Key ideas include a) water chemistry has an influence on life processes; b) macromolecules have roles in maintaining life processes; c) enzymes have a role in biochemical processes; d) protein synthesis is the process of forming proteins which influences inheritance and evolution; and e) the processes of photosynthesis and respiration include the capture, storage, transformation, and flow of energy.
 BIO.3 The student will investigate and understand relationships between cell structure and function. Key concepts include a) evidence supporting the cell theory; b) characteristics of prokaryotic and eukaryotic cells; c) similarities between the activities of the organelles in a single cell and a whole organism; 	 BIO.3 The student will investigate and understand that cells have structure and function. Key ideas include a) the cell theory is supported by evidence; b) structures in unicellular and multicellular organisms work interdependently to carry out life processes;

2010	2018
d) the cell membrane model; and	c) cell structures and processes are involved in cell growth and
e) the impact of surface area to volume ratio on cell	division;
division, material transport, and other life processes.	d) the structure and function of the cell membrane support cell
	transport; and
	e) specialization leads to the development of different types of
	cells.
	BIO.4 The student will investigate and understand that bacteria and
	viruses have an effect on living systems. Key ideas include
	a) viruses depend on a host for metabolic processes;
	b) the modes of reproduction/replication can be compared;
	c) the structures and functions can be compared;
	d) bacteria and viruses have a role in other organisms and the
	environment; and
DIO 4 The student will investigate and understand life functions	e) the germ theory of infectious disease is supported by evidence.
of Archaea Pactoria and Eukarua Kay concepts include	
of Archaea, Bacterra and Eukarya. Key concepts include	
a) comparison of their metabolic activities:	
b) maintenance of homeostasis:	
c) how the structures and functions vary among and	
within the Eukarya kingdoms of protists, fungi, plants,	
and animals, including humans;	
d) human health issues, human anatomy, and body	
systems;	
e) how viruses compare with organisms; and	
f) evidence supporting the germ theory of infectious	
disease.	
BIO.5 The student will investigate and understand common	BIO.5 The student will investigate and understand that there are common
mechanisms of inheritance and protein synthesis. Key	mechanisms for inheritance. Key ideas include
concepts include	a) DNA has structure and is the foundation for protein synthesis;
a) cell growth and division;	b) the structural model of DNA has developed over time;
b) gamete formation;	c) the variety of traits in an organism are the result of the
c) cell specialization;	expression of various combinations of alleles;
	d) meiosis has a role in genetic variation between generations; and

2010	2018
 d) prediction of inheritance of traits based on the Mendelian laws of heredity; e) historical development of the structural model of DNA; f) genetic variation; g) the structure, function, and replication of nucleic acids; h) events involved in the construction of proteins; i) use, limitations, and misuse of genetic information; and j) exploration of the impact of DNA technologies. BIO.6 The student will investigate and understand bases for modern classification systems. Key concepts include a) structural similarities among organisms; b) fossil record interpretation; c) comparison of developmental stages in different organisms; d) examination of biochemical similarities and differences among organisms; and e) systems of classification that are adaptable to new scientific discoveries. 	 e) synthetic biology has biological and ethical implications. e) synthetic biology has biological and ethical implications. BIO.6 The student will investigate and understand that modern classification systems can be used as organizational tools for scientists in the study of organisms. Key ideas include a) organisms have structural and biochemical similarities and differences; b) fossil record interpretation can be used to classify organisms; c) developmental stages in different organisms can be used to classify organisms; d) Archaea, Bacteria, and Eukarya are domains based on characteristics of organisms; e) the functions and processes of protists, fungi, plants, and animals allow for comparisons and differentiation within the Eukarya kingdoms; and f) systems of classification are adaptable to new scientific discoveries.
 BIO.7 The student will investigate and understand how populations change through time. Key concepts include a) evidence found in fossil records; b) how genetic variation, reproductive strategies, and environmental pressures impact the survival of populations; c) how natural selection leads to adaptations; d) emergence of new species; and e) scientific evidence and explanations for biological evolution. 	 BIO.7 The student will investigate and understand that populations change through time. Key ideas include a) evidence is found in fossil records and through DNA analysis; b) genetic variation, reproductive strategies, and environmental pressures affect the survival of populations; c) natural selection is a mechanism that leads to adaptations and may lead to the emergence of new species; and d) biological evolution has scientific evidence and explanations.

2010	2018	
BIO.8 The student will investigate and understand dynamic	BIO.8 The student will investigate and understand that there are dynamic	
equilibria within populations, communities, and	equilibria within populations, communities, and ecosystems. Key	
ecosystems. Key concepts include	ideas include	
a) interactions within and among populations including carrying capacities, limiting factors, and growth curves;	a) interactions within and among populations include carrying capacities, limiting factors, and growth curves;	
b) nutrient cycling with energy flow through ecosystems;	b) nutrients cycle with energy flow through ecosystems;	
c) succession patterns in ecosystems;	c) ecosystems have succession patterns; and	
d) the effects of natural events and human activities on ecosystems; and	d) natural events and human activities influence local and global ecosystems and may affect the flora and fauna of Virginia.	
e) analysis of the flora, fauna, and microorganisms of		
Virginia ecosystems.		

Chemistry Cross Walk

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Chemistry:

- Redundant content from physical science standards was removed. An example is that the parts of the atom have been removed from the Chemistry standards and curriculum framework. The expectation is that students are taught this content in Physical Science. Pre-assessments should be used to determine any needed remediation/re-teaching that is needed to support instruction and build on foundational understandings of a concept.
- Content was reorganized to form standards on solutions (CH.5) and thermochemistry (CH.7).
- Organic chemistry from the previous CH.6 was integrated into existing standards.
- Equilibrium was removed from chemistry standards. Although it was removed, teachers may still teach the concept of chemical equilibrium.

	2010		2018
CH.1	The student will investigate and understand that	CH.1	The student will demonstrate an understanding of scientific and
	experiments in which variables are measured, analyzed, and		engineering practices by
	evaluated produce observations and verifiable data. Key		a) asking questions and defining problems
	concepts include		• ask questions that arise from careful observation of
	n) designated laboratory techniques;		phenomena, examination of a model or theory,
	o) safe use of chemicals and equipment;		unexpected results, and/or to seek additional information
	p) proper response to emergency situations;		• determine which questions can be investigated within
	q) manipulation of multiple variables, using repeated trials;		the scope of the school laboratory

2010	2018
 r) accurate recording, organization, and analysis of data through repeated trials; s) mathematical and procedural error analysis; 	• make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated
 accurate recording, organization, and analysis of data through repeated trials; mathematical and procedural error analysis; mathematical manipulations including SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, and dimensional analysis; use of appropriate technology including computers, graphing calculators, and probeware, for gathering data, communicating results, and using simulations to model concepts; construction and defense of a scientific viewpoint; and w) the use of current applications to reinforce chemistry concepts. 	 make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated generate hypotheses based on research and scientific principles define design problems that involve the development of a process or system with interacting components, criteria and constraints b) planning and carrying out investigations individually and collaboratively plan and conduct observational and experimental investigations plan and conduct investigations or test design solutions in a safe manner, including planning for response to emergency situations select and use appropriate tools and technology to collect, record, analyze, and evaluate data record and present data in an organized format that communicates relationships and quantities in appropriate mathematical or algebraic forms use data in building and revising models, supporting explanations for phenomena, or testing solutions to problems solve problems using mathematical manipulations including the International System of Units (SI), scientific notation, derived units, significant digits, and
	 analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution analyze data graphically and use graphs to make

2010	2018
	differentiate between accuracy and precision of
	measurements
	• consider limitations of data analysis when analyzing
	and interpreting data
	 analyze data to optimize a design
	d) constructing and critiquing conclusions and explanations
	• construct and revise explanations based on valid and
	reliable evidence obtained from a variety of sources
	• apply scientific ideas, principles, and/or evidence to
	provide an explanation of phenomena or design solutions
	• compare and evaluate competing arguments in light of
	currently accepted explanations and new scientific evidence
	• construct arguments or counterarguments based on
	data and evidence
	 differentiate between scientific hypothesis, theory, and law
	e) developing and using models
	• evaluate the merits and limitations of models
	• develop, revise, and/or use models based on evidence
	to illustrate or predict relationships
	• use models and simulations to visualize and explain the
	movement of particles, to represent chemical reactions,
	to formulate mathematical equations, and to interpret
	data sets
	f) obtaining, evaluating, and communicating information
	• compare, integrate, and evaluate sources of information
	scientific question or solve a problem
	ather read and evaluate scientific and/or technical
	information from multiple authoritative sources
	assessing the evidence and credibility of each source

2010	2018
	• communicate scientific and/or technical information about phenomena and/or a design process in multiple formats
 CH.2 The student will investigate and understand that the placement of elements on the periodic table is a function of their atomic structure. The periodic table is a tool used for the investigations of a) average atomic mass, mass number, and atomic number; b) isotopes, half lives, and radioactive decay; c) mass and charge characteristics of subatomic particles; d) families or groups; e) periods; f) trends including atomic radii, electronegativity, shielding effect, and ionization energy; g) electron configurations, valence electrons, and oxidation numbers; h) chemical and physical properties; and i) historical and quantum models. 	 CH.2 The student will investigate and understand that elements have properties based on their atomic structure. The periodic table is an organizational tool for elements based on these properties. Key information pertaining to the periodic table includes a) average atomic mass, isotopes, mass number, and atomic number; b) nuclear decay; c) trends within groups and periods including atomic radii, electronegativity, shielding effect, and ionization energy; d) electron configurations, valence electrons, excited electrons, and ions; and e) historical and quantum models.
 CH.3 The student will investigate and understand how conservation of energy and matter is expressed in chemical formulas and balanced equations. Key concepts include a) nomenclature; b) balancing chemical equations; c) writing chemical formulas; d) bonding types; e) reaction types; and f) reaction rates, kinetics, and equilibrium. 	 CH.3 The student will investigate and understand that atoms are conserved in chemical reactions. Knowledge of chemical properties of the elements can be used to describe and predict chemical interactions. Key ideas include a) chemical formulas are models used to represent the number of each type of atom in a substance; b) substances are named based on the number of atoms and the type of interactions between atoms; c) balanced chemical equations model rearrangement of atoms in chemical reactions; d) atoms bond based on electron interactions; e) molecular geometry is predictive of physical and chemical properties; and f) reaction types can be predicted and classified.

	2010		2018
CH.4	 The student will investigate and understand that chemical quantities are based on molar relationships. Key concepts include a) Avogadro's principle and molar volume; b) stoichiometric relationships; c) solution concentrations; and d) acid/base theory; strong electrolytes, weak electrolytes, and nonelectrolytes; dissociation and ionization; pH and pOH; and the titration process. 	CH.4	 The student will investigate and understand that molar relationships compare and predict chemical quantities. Key ideas include a) Avogadro's principle is the basis for molar relationships; and b) stoichiometry mathematically describes quantities in chemical composition and in chemical reactions.
		CH.5	 The student will investigate and understand that solutions behave in predictable and quantifiable ways. Key ideas include a) molar relationships determine solution concentration; b) changes in temperature can affect solubility; c) extent of dissociation defines types of electrolytes; d) pH and pOH quantify acid and base dissociation; and e) colligative properties depend on the extent of dissociation.
CH.5	The student will investigate and understand that the phases of matter are explained by kinetic theory and forces of attraction between particles. Key concepts include a) pressure, temperature, and volume; b) partial pressure and gas laws; c) vapor pressure; d) phase changes; e) molar heats of fusion and vaporization; f) specific heat capacity; and g) colligative properties.	CH.6	 The student will investigate and understand that the phases of matter are explained by the kinetic molecular theory. Key ideas include a) pressure and temperature define the phase of a substance; b) properties of ideal gases are described by gas laws; and c) intermolecular forces affect physical properties.
		CH.7	 The student will investigate and understand that thermodynamics explains the relationship between matter and energy. Key ideas include a) heat energy affects matter and interactions of matter; b) heating curves provide information about a substance; c) reactions are endothermic or exothermic; d) energy changes in reactions occur as bonds are broken and formed;

	2010	2018
		e) collision theory predicts the rate of reactions;
		f) rates of reactions depend on catalysts and activation
		energy; and
		g) enthalpy and entropy determine the extent of a reaction.
CH.6	The student will investigate and understand how basic	
	chemical properties relate to organic chemistry and	
	biochemistry. Key concepts include	
	a) unique properties of carbon that allow multi-carbon	
	compounds; and	
	b) uses in pharmaceuticals and genetics, petrochemicals,	
	plastics, and food.	

Earth Science Cross Walk

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- In studying the historical developments of current science concepts, instructional emphasis should be placed on the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Earth Science:

- The content of the previous ES.2 was incorporated ES.1.
- The order of the standards was revised and the origin of the universe (ES.13) has been incorporated into ES.2.
- Global warming is explicitly addressed in ES.12.
- Greater emphasis on human influence on atmospheric composition and dynamics was added into ES.11.

2010		2018	
ES.1	The student will plan and conduct investigations in which	ES.1	The student will demonstrate an understanding of scientific and
	a) volume, area, mass, elapsed time, direction, temperature,		engineering practices by
	pressure, distance, density, and changes in		a) asking questions and defining problems
	elevation/depth are calculated utilizing the most		• ask questions that arise from careful observation of
	appropriate tools;		phenomena, examination of a model or theory, or
	b) technologies, including computers, probeware, and		unexpected results, and/or to seek additional information
	geospatial technologies, are used to collect, analyze, and		• determine which questions can be investigated within the
	report data and to demonstrate concepts and simulate		scope of the school laboratory or field experience
	experimental conditions;		• generate hypotheses based on research and scientific
	c) scales, diagrams, charts, graphs, tables, imagery,		principles
	models, and profiles are constructed and interpreted;		

2010	2018
 d) maps and globes are read and interpreted, including location by latitude and longitude; e) variables are manipulated with repeated trials; and f) current applications are used to reinforce Earth science concepts. 	 make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated define design problems that involve the development of a process or system with multiple components and criteria planning and carrying out investigations individually and collaboratively plan and conduct observational and experimental investigations plan and conduct investigations to test design solutions in a safe and ethical manner including considerations of environmental, social and personal effects select and use appropriate tools and technology to collect, record, analyze, and evaluating data construct and interpret data tables showing independent and dependent variables, repeated trials, and means construct, analyze, and interpret graphical displays of data and consider limitations of data analysis apply mathematical concepts and processes to scientific questions use data in building and revising models, supporting explanations of phenomena, or testing solutions to problems analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims or determine an optimal design solution construct and revise explanations based on data construct and revise explanations based on valid and reliable evidence obtained from a variety of sources, including students' own investigations, models, theories, directed from a variety of sources, including students' own investigations, models, theories, directed from a variety of sources, including students' own investigations, andels, theories, directed from a variety of sources, including students' own investigations, models, theories, directed from a variety of sources, including students' own investigations, models, theories, directed from a variety of sources, including students' own investigations, models, theories, directed from a variety of sources, including students' own investigations, models, theories,

2010	2018
	 apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena or design solutions construct arguments or counterarguments based on data and evidence differentiate between a scientific hypothesis, theory, and law e) developing and using models evaluate the merits and limitations of models develop, revise, and/or use models based on evidence to illustrate or predict relationships construct and interpret scales, diagrams, classification charts, graphs, tables, imagery, models, including geologic cross sections and topographic profiles read and interpret topographic and basic geologic maps and globes, including location by latitude and longitude f) obtaining, evaluating, and communicating information compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem gather, read, and evaluate scientific and/or technical information from multiple sources, assessing the evidence and credibility of each source communicate scientific and/or technical information about phenomena and/or a design process in multiple formate
 ES.2 The student will demonstrate an understanding of the nature of science and scientific reasoning and logic. Key concepts include a) science explains and predicts the interactions and dynamics of complex Earth systems; b) evidence is required to evaluate hypotheses and explanations; c) observation and logic are essential for reaching a conclusion; and 	

	2010		2018
	d) evidence is evaluated for scientific theories.		
ES.3	The student will investigate and understand the characteristics of Earth and the solar system. Key concepts include	ES.2	The student will demonstrate an understanding that there are scientific concepts related to the origin and evolution of the universe. Key ideas include
	 a) position of Earth in the solar system; b) sun-Earth-moon relationships; (seasons, tides, and eclipses); c) characteristics of the sun, planets and their moons, comets, meteors, and asteroids; and d) the history and contributions of space exploration. 		 a) the big bang theory explains the origin of universe; b) stars, star systems, and galaxies change over long periods of time; c) characteristics of the sun, planets and their moons, comets, meteors, asteroids, and dwarf planets are determined by materials found in each body; and
ES.13	The student will investigate and understand scientific concepts related to the origin and evolution of the universe.		d) evidence from space exploration has increased our understanding of the structure and nature of our universe.
	Key concepts include a) cosmology including the Big Bang theory; and	ES.3	The student will investigate and understand that Earth is unique in our solar system. Key ideas include
	b) the origin and evolution of stars, star systems, and galaxies.		a) Earth supports life because of its relative proximity to the sun and other factors; andb) the dynamics of the sun-Earth-moon system cause seasons, tides, and eclipses
ES.4	 The student will investigate and understand how to identify major rock-forming and ore minerals based on physical and chemical properties. Key concepts include a) hardness, color and streak, luster, cleavage, fracture, and unique properties; and b) uses of minerals. 	ES.4	 The student will investigate and understand that there are major rock-forming and ore minerals. Key ideas include a) analysis of physical and chemical properties supports mineral identification; b) characteristics of minerals determine the uses of minerals; and c) minerals originate and are formed in specific ways.
ES.5	The student will investigate and understand the rock cycle as it relates to the origin and transformation of rock types and how to identify common rock types based on mineral composition and textures. Key concepts include a) igneous rocks; b) sedimentary rocks; and c) metamorphic rocks.	ES.5	 The student will investigate and understand that igneous, metamorphic, and sedimentary rocks can transform. Key ideas include a) Earth materials are finite and are transformed over time; b) the rock cycle models the transformation of rocks; c) layers of Earth have rocks with specific chemical and physical properties; and

	2010		2018
			d) plate tectonic and surface processes transform Earth materials.
ES.6	 The student will investigate and understand the differences between renewable and nonrenewable resources. Key concepts include a) fossil fuels, minerals, rocks, water, and vegetation; b) advantages and disadvantages of various energy sources; c) resources found in Virginia; and d) environmental costs and benefits. 	ES.6	 The student will investigate and understand that resource use is complex. Key ideas include a) global resource use has environmental liabilities and benefits; b) availability, renewal rates, and economic effects are considerations when using resources; c) use of Virginia resources has an effect on the environment and the economy; and d) all energy sources have environmental and economic effects.
ES.7	The student will investigate and understand geologic processes including plate tectonics. Key concepts include a) geologic processes and their resulting features; and b) tectonic processes.	ES.7	 The student will investigate and understand that plate tectonic theory explains Earth's internal and external geologic processes. Key ideas include a) convection currents in Earth's interior lead to the movement of plates and influence the distribution of materials in Earth's layers, and may impact the magnetic field; b) features and processes occur within plates and at plate boundaries; c) interaction between tectonic plates causes the development of mountain ranges and ocean basins; and d) evidence of geologic processes is found in Virginia's geologic landscape.
ES.8	 The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts include a) processes of soil development; b) development of karst topography; c) relationships between groundwater zones, including saturated and unsaturated zones, and the water table; d) identification of sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle; 	ES.8	 The student will investigate and understand that freshwater resources influence and are influenced by geologic processes and human activity. Key ideas include a) water influences geologic processes including soil development and karst topography; b) the nature of materials in the subsurface affect the water table and future availability of fresh water; c) weather and human usage affect freshwater resources, including water locations, quality, and supply; and

2010	2018
 e) dependence on freshwater resources and the effects of human usage on water quality; and f) identification of the major watershed systems in Virginia, including the Chesapeake Bay and its tributaries. 	 d) stream processes and dynamics affect the major watershed systems in Virginia, including the Chesapeake Bay and its tributaries.
 ES.9 The student will investigate and understand that many aspects of the history and evolution of Earth and life can be inferred by studying rocks and fossils. Key concepts include a) traces and remains of ancient, often extinct, life are preserved by various means in many sedimentary rocks; b) superposition, cross-cutting relationships, index fossils, and radioactive decay are methods of dating bodies of rock; c) absolute and relative dating have different applications but can be used together to determine the age of rocks and structures; and d) rocks and fossils from many different geologic periods and epochs are found in Virginia. 	 ES.9 The student will investigate and understand that many aspects of the history and evolution of Earth and life can be inferred by studying rocks and fossils. Key ideas include a) traces and remains of ancient, often extinct, life are preserved by various means in sedimentary rocks; b) superposition, cross-cutting relationships, index fossils, and radioactive decay are methods of dating rocks and Earth events and processes; c) absolute (radiometric) and relative dating have different applications but can be used together to determine the age of rocks and structures; and d) rocks and fossils from many different geologic periods and epochs are found in Virginia.
 ES.10 The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include a) physical and chemical changes related to tides, waves, currents, sea level and ice cap variations, upwelling, and salinity variations; b) importance of environmental and geologic implications; c) systems interactions; d) features of the sea floor as reflections of tectonic processes; and e) economic and public policy issues concerning the oceans and the coastal zone including the Chesapeake 	 ES.10 The student will investigate and understand that oceans are complex, dynamic systems and are subject to long- and short-term variations. Key ideas include a) chemical, biological, and physical changes affect the oceans; b) environmental and geologic occurrences affect ocean dynamics; c) unevenly distributed heat in the oceans drives much of Earth's weather; d) features of the sea floor reflect tectonic and other geological processes; and e) human actions, including economic and public policy issues, affect oceans and the coastal zone including the Chesapeake

2010	2018
 ES.11 The student will investigate and understand the origin and evolution of the atmosphere and the interrelationship of geologic processes, biologic processes, and human activities on its composition and dynamics. Key concepts include a) scientific evidence for atmospheric composition changes over geologic time; b) current theories related to the effects of early life on the chemical makeup of the atmosphere; c) atmospheric regulation mechanisms including the effects of density differences and energy transfer; and 	 ES.11 The student will investigate and understand that the atmosphere is a complex, dynamic system and is subject to long-and short-term variations. Key ideas include a) the composition of the atmosphere is critical to most forms of life; b) biologic and geologic interactions over long and short time spans change the atmospheric composition; c) natural events and human actions may stress atmospheric regulation mechanisms; and d) human actions, including economic and policy decisions,
d) potential changes to the atmosphere and climate due to human, biologic, and geologic activity.	affect the atmosphere.
 ES.12 The student will investigate and understand that energy transfer between the sun and Earth and its atmosphere drives weather and climate on Earth. Key concepts include a) observation and collection of weather data; b) prediction of weather patterns; c) severe weather occurrences, such as tornadoes, hurricanes, and major storms; and d) weather phenomena and the factors that affect climate including radiation, conduction, and convection. 	 ES.12 The student will investigate and understand that Earth's weather and climate are the result of the interaction of the sun's energy with the atmosphere, oceans, and the land. Key ideas include a) weather involves the reflection, absorption, storage, and redistribution of energy over short to medium time spans; b) weather patterns can be predicted based on changes in current conditions; c) extreme imbalances in energy distribution in the oceans, atmosphere, and the land may lead to severe weather conditions; d) models based on current conditions are used to predict weather phenomena; and e) changes in the atmosphere and the oceans due to natural and human activity affect global climate.

Physics Cross Walk

General changes evidenced in the Virginia 2018 Science Standards of Learning:

- The 2018 Science Standards of Learning have been restructured to support the development of concepts versus a focus on terminology. The introduction of terms as students develop conceptual understanding through engaging in science and engineering practices is a research based best practice in science instruction. The practice of introducing scientific terms and their definitions at the beginning of a unit is proven to be an ineffective instructional strategy in science education.
- The section Scientific Investigation, Reasoning, and Logic has been changed to Scientific and Engineering Practices. The expectation is that these practices are integrated to support and enhance the concepts within the standards.
- Study of the historical developments of current science concepts should emphasize the nature of science and the contributions that led to the development of the scientific concept, theory, or law versus the identification of specific scientists or events.

Summary of changes specific to Physics:

- The 2010 standards PH.1-4 were reorganized and incorporated into PH.1.
- The phrase "The student will investigate and understand, through mathematical and experimental processes...." was added to the stems.
- Optical systems was added to standards.
- Specific content on electromagnetic radiation was built into light waves and the transmission of energy in PH.5.
- The last standard, PH.9 was updated to reflect more modern physics. The update includes the standard model and dark matter and dark energy.
- The 2010 standard of PH.5 was split into two standards: one (PH.2) focusing on the relationships between position and time; one (PS.3) focusing on the relationship between force, mass, and acceleration.

	2010		2018
PH.1	The student will plan and conduct investigations using	PH.1	The student will demonstrate an understanding of scientific and
	experimental design and product design processes. Key		engineering practices by.
	concepts include		a) asking questions and defining problems
	a) the components of a system are defined;		• ask questions that arise from careful observation of
	b) instruments are selected and used to extend		phenomena, examination of a model or theory, unexpected
	observations and measurements;		results, and/or to seek additional information
	c) information is recorded and presented in an organized		• determine which questions can be investigated within the
	format;		scope of the school laboratory

2010	2018
 d) the limitations of the experimental apparatus and design are recognized; e) the limitations of measured quantities are recognized through the appropriate use of significant figures or 	 make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated generate hypotheses based on research and scientific principles
 through the appropriate use of significant figures or error ranges; f) models and simulations are used to visualize and explain phenomena, to make predictions from hypotheses, and to interpret data; and g) appropriate technology, including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results. 	 define design problems that involves the development of a process or system with interacting components and criteria and constraints b) planning and carrying out investigations individually and collaboratively plan and conduct observational and experimental investigations plan and conduct investigations or test design solutions in a safe manner select and use appropriate tools and technology to collect, record, analyze, and evaluate data c) interpreting, analyzing, and evaluating data record and present data in an organized format that communicates relationships and quantities in appropriate mathematical or algebraic forms use data in building and revising models, supporting an explanation for phenomena, or testing solutions to problems analyze data using tools, technologies, and/or models (e.g., computational, mathematical, statistical) in order to make valid and reliable scientific claims or determine an optimal design solution analyze data graphically and use graphs to make predictions consider limitations of data analysis when analyzing and interpreting data evaluate the effects of new data on a working explanation and/or model of a proposed process or system analyze data to optimize a design

2010	2018
	 construct and revise explanations based on valid and reliable evidence obtained from a variety of sources apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena or design solutions compare and evaluate competing arguments in light of currently accepted explanations and new scientific evidence construct arguments or counterarguments based on data and evidence differentiate between scientific hypothesis, theory, and law e) developing and using models evaluate the merits and limitations of models identify and communicate components of a system orally, graphically, textually, and mathematically develop and/or use models (including mathematical and computational) and simulations to visualize, explain, and predict phenomena and to interpret data sets f) obtaining, evaluating, and communicating information compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source communicate scientific and/or technical information about phenomena and/or a design process in multiple formats
 PH.2 The student will investigate and understand how to analyze and interpret data. Key concepts include a) a description of a physical problem is translated into a mathematical statement in order to find a solution; b) relationships between physical quantities are determined using the shape of a curve passing through 	
experimentally obtained data;c) the slope of a linear relationship is calculated and includes appropriate units;	

	2010	2018
	d) interpolated, extrapolated, and analyzed trends are	
	used to make predictions; and	
	e) situations with vector quantities are analyzed utilizing	
	trigonometric or graphical methods.	
PH.3	The student will investigate and demonstrate an	
	understanding of the nature of science, scientific	
	reasoning, and logic. Key concepts include	
	a) analysis of scientific sources to develop and refine research hypotheses;	
	b) analysis of how science explains and predicts relationships;	
	c) evaluation of evidence for scientific theories;	
	d) examination of how new discoveries result in	
	modification of existing theories or establishment of	
	new paradigms; and	
	e) construction and defense of a scientific viewpoint.	
PH.4	The student will investigate and understand how	
	applications of physics affect the world. Key concepts	
	include	
	a) examples from the real world; and	
	b) exploration of the roles and contributions of science and technology.	
PH.5	The student will investigate and understand the	PH.2 The student will investigate and understand, through mathematical
	interrelationships among mass, distance, force, and time	and experimental processes, that there are relationships between
	through mathematical and experimental processes. Key	position and time. Key topics include
	concepts include	a) displacement, velocity, and uniform acceleration;
	a) linear motion;	b) linear motion;
	b) uniform circular motion;	c) uniform circular motion; and
	c) projectile motion;	d) projectile motion.
	d) Newton's laws of motion;	
	e) gravitation;	
	f) planetary motion; and	
	g) work, power, and energy.	

	2010		2018
		PH.3	The student will investigate and understand, through mathematical and experimental processes, that there are relationships among force, mass, and acceleration. Key laws includea) Newton's Laws of Motion; andb) Newton's Law of Universal Gravitation.
PH.6	 The student will investigate and understand that quantities including mass, energy, momentum, and charge are conserved. Key concepts include a) kinetic and potential energy; b) elastic and inelastic collisions; and c) mass/energy equivalence. 	PH.4	 The student will investigate and understand, through mathematical and experimental processes, that conservation laws govern all interactions. Key ideas include a) momentum is conserved unless an impulse acts on the system; and b) mechanical energy is conserved unless work is done on, by, or within the system.
PH.7	 The student will investigate and understand that energy can be transferred and transformed to provide usable work. Key concepts include a) transfer and storage of energy among systems including mechanical, thermal, gravitational, electromagnetic, chemical, and nuclear systems; and b) efficiency of systems. 		
PH.8	 The student will investigate and understand wave phenomena. Key concepts include a) wave characteristics; b) fundamental wave processes; and c) light and sound in terms of wave models. 	PH.5	 The student will investigate and understand, through mathematical and experimental processes, that waves transmit energy and move in predictable patterns. Key ideas include a) waves have specific characteristics; b) wave interactions are part of everyday experiences; and c) light and sound transmit energy as waves.
		PH.6	The student will investigate and understand, through mathematical and experimental processes, that optical systems form a variety of images. Key ideas includea) the laws of reflection and refraction describe light behavior; andb) ray diagrams model light as it travels through different media.
PH.9	The student will investigate and understand that different frequencies and wavelengths in the electromagnetic spectrum are phenomena ranging from radio waves		

2010	2018
through visible light to gamma radiation. Key concepts include	
a) the properties, behaviors, and relative size of radio	
waves, microwaves, infrared, visible light, ultraviolet,	
X-rays, and gamma rays;	
b) wave/particle dual nature of light; and	
c) current applications based on the respective wavelengths.	
PH.10 The student will investigate and understand how to use the	PH.7 The student will investigate and understand, through mathematical
field concept to describe the effects of gravitational,	and experimental processes, that fields provide a unifying
electric, and magnetic forces. Key concepts include	description of force at a distance. Key ideas include
a) inverse square laws (Newton's law of universal	a) gravitational, electric, and magnetic forces can be described
gravitation and Coulomb's law); and	using the field concept; and
b) technological applications.	b) field strength diminishes with increased distance from the source.
PH.11 The student will investigate and understand how to	PH.8 The student will investigate and understand, through mathematical
diagram, construct, and analyze basic electrical circuits	and experimental processes, that electrical circuits are a system
and explain the function of various circuit components.	used to transfer energy. Key ideas include
Key concepts include	a) circuit components have different functions within the system;
a) Ohm's law;	b) Ohm's law relates voltage, current, and resistance;
b) series, parallel, and combined circuits;	c) different types of circuits have different characteristics and are
c) electrical power; and	used for different purposes;
d) alternating and direct currents.	d) electrical power is related to the elements in a circuit; and
	e) electrical circuits have everyday applications.
PH.12 The student will investigate and understand that extremely	PH.9 The student will investigate and understand that extremely large
large and extremely small quantities are not necessarily	and extremely small quantities are not necessarily described by the
described by the same laws as those studied in Newtonian	same laws as those studied in Newtonian physics. Topics, such as
physics. Key concepts may include	these listed, may be included.
a) wave/particle duality;	a) wave/particle duality;
a) matter/opergy equivalence:	a) relativity:
d) quantum mechanics and uncertainty:	d) nuclear physics:
e) relativity:	e) solid state physics:
f) nuclear physics:	f) nanotechnology:

2010	2018
g) solid state physics;	g) superconductivity;
h) nanotechnology;	h) the standard model; and
i) superconductivity; and	i) dark matter and dark energy.
j) radioactivity.	