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Time Frame	SOL Objective	Essential Understandings	Essential Knowledge/Skills
Introduce and On-going	6.1	The concepts developed in this standard include the following: • The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world. The nature of science includes the following concepts a) the natural world is understandable; b) science is based on evidence, both observational and experimental; c) science is a blend of logic and innovation; d) scientific ideas are durable yet subject to change as new data are collected; e) science is a complex social endeavor; and f) scientists try to remain objective and engage in peer review to help avoid bias. • To communicate an observation accurately, one must provide critical details of exactly what is being observed. Using that information, students will be able to differentiate definitively between or among similar objects and/or organisms. • Systematic investigations require accurate measurements; however, in the absence of precision tools, observers must record careful estimations. • Scale models must maintain relative values of size and/or quantity in order to maintain the integrity of the object or topic being modeled. • An experiment is a structured test of a hypothesis. A hypothesis is stated in terms of a testable relationship. • A scientific prediction is a forecast about what may happen in some future situation. It is based on the application of scientific principle and factual information. • An inference is an explanation based on observations and background knowledge. A conclusion is formulated from collected data. For example, one might observe darkly colored pond water and make the inference that it is polluted. However, only after data are collected can a conclusion be formulated. • Patterns discerned from direct observations can be the basis for predictions or hypotheses that attempt to explain the mechanism responsible for the pattern. • Accurate observations and evidence are necessary to draw realistic and plausible conclusions.	In order to meet this standard, it is expected that students will • make connections between the components of the nature of science and their investigations and the greater body of scientific knowledge and research. • make observations that can be used to discriminate similar objects and organisms, paying attention to fine detail. • make precise and consistent measurements and estimations. • create approximate scale models to demonstrate an understanding of distance, volume, and quantity. • differentiate between independent and dependent variables in a hypothesis. • propose hypotheses or predictions from observed patterns. • compare and contrast predictions and inferences. Analyze and judge the evidence, observations, scientific principles, and data used in making predictions and inferences. • design an experiment in which one variable is manipulated over many trials. • collect, record, analyze, and report data, using metric terminology and tools. • analyze and communicate data, using graphs (bar, line, and circle), charts, and diagrams. • design a model that explains a sequence, for example, the sequence of events involved in the formation of a cloud.

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		• In order to conduct an experiment, one must recognize all of the potential variables that can affect an outcome. • In a scientific investigation, data should be collected, recorded, analyzed, and reported using appropriate metric measurement and tools. • In a scientific investigation, data should be organized and communicated through appropriate graphical representation (graph, chart, table, and diagram). • Models provide a way of visually representing abstract concepts. The use of models permits students to order events or processes. • Science concepts are applied through observations and connections with everyday life and technology.	

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Time Frame	SOL Objective	Essential Understandings	Essential Knowledge/Skills
2 weeks and on-going	6.6	The concepts developed in this standard include the following: • Air is a mixture of gaseous elements and compounds. These include nitrogen, oxygen, water, argon and carbon dioxide. Nitrogen makes up the largest proportion of air. • Air exerts pressure. Air pressure decreases as altitude increases. • Moisture in the air is called humidity. • The atmosphere is made up of layers (troposphere, stratosphere, mesosphere, and thermosphere) that have distinct characteristics. • Temperature decreases as altitude increases in the lowest layer of the atmosphere. • Most of the air that makes up the atmosphere is found in the troposphere (the lowest layer). Virtually all weather takes place there. • Forest fires and volcanic eruptions are two natural processes that affect Earth's atmosphere. Many gaseous compounds and particles are released into the atmosphere by human activity. All of the effects of these materials are not yet fully understood. • The amounts of thermal energy and water vapor in the air and the pressure of the air largely determine what the weather conditions are. • Clouds are important indicators of atmospheric conditions. Clouds are found at various levels within the troposphere. Three major types of clouds are cumulus, stratus, and cirrus. • Ozone, a form of oxygen, can form near the surface when exhaust pollutants react with sunlight. This pollutant can cause health problems. Naturally occurring ozone is also found in the upper atmosphere and helps to shield Earth from ultraviolet radiation. • Maintaining good air quality is a crucial goal for modern society, and it is everyone's responsibility to work toward it. • Weather maps show much useful information about descriptive air measurements, observations, and boundaries between air masses (fronts). The curved lines showing areas of equal air pressure and temperature are key features of weather maps. Weather maps are important for understanding and predicting the weather.	In order to meet this standard, it is expected that students will • comprehend and apply basic terminology related to air and the atmosphere. • identify the composition and physical characteristics of the atmosphere. • analyze and interpret charts and graphs of the atmosphere in terms of temperature and pressure. • measure and record air temperature, air pressure, and humidity, using appropriate units of measurement and tools. • analyze and explain some of the effects that natural events and human activities may have on weather, atmosphere, and climate. • evaluate their own roles in protecting air quality. • design an investigation to relate temperature, barometric pressure, and humidity to changing weather conditions. • compare and contrast cloud types and relate cloud types to weather conditions. • compare and contrast types of precipitation. • compare and contrast weather-related phenomena, including thunderstorms, tornadoes, hurricanes, and drought. • interpret basic weather maps and make forecasts based on the information presented. • map the movement of cold and warm fronts and interpret their effects on observable weather conditions.

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Time Frame	SOL Objective	Essential Understandings	Essential Knowledge/Skills
2 weeks	6.5	The concepts developed in this standard include the following: • Among water's unique properties is that one side of each water molecule is slightly negative and the other is slightly positive. Individual water molecules, therefore, attract other water molecules like little magnets as the slightly positive portion of a water molecule is attracted to the slightly negative portion of an adjacent water molecule. In this way, water molecules "stick together." • Due to water's polar nature, a large number of substances will "dissolve" in water. For this reason, water is often called the universal solvent. • Water is the only compound that commonly exists in all three states (solid, liquid, gas) on Earth. The unique properties of water are a major factor in the ability of our planet to sustain life. • Additional properties of water are its high surface tension and the large range of temperature (0–100 degrees Celsius) in which it can be found in the liquid state, as well as the fact that, unlike other substances, solid water is less dense than liquid water. • Water is able to absorb thermal energy without showing relatively large changes in temperature. Large bodies of water act to moderate the climate of surrounding areas by absorbing thermal energy in summer and slowly releasing that energy in the winter. For this reason, the climate near large bodies of water is slightly milder than areas without large bodies of water. • Water (rain, ice, snow) has shaped our environment by physically and chemically weathering rock and soil and transporting sediments. Freezing water can break rock without any change in the minerals that form the rock (physical weathering). This usually produces small particles and sand. Water with dissolved gases and other chemicals causes the minerals in rocks to be changed, leading to the deterioration of the rock (chemical weathering). • Most of Earth's water is salt water in the oceans (97 percent). Nonfrozen, fresh water makes up less than 1 percent of the water on Earth. • Water is essential for agriculture. Crops watered by reliable irrigation systems are more productive and harvests more dependable.	In order to meet this standard, it is expected that students will • comprehend and apply key terminology related to water and its properties and uses. • model and explain the shape and composition of a water molecule. • design an investigation to demonstrate the ability of water to dissolve materials. • comprehend the adhesive and cohesive properties of water. • compare the effects of adding thermal energy to the states of water. • explain why ice is less dense than liquid water. • relate the three states of water to the water cycle. • design an investigation to model the action of freezing water on rock material. • design an investigation to determine the presence of water in plant material (e.g., a fruit). • infer how the unique properties of water are key to the life processes of organisms. • design an investigation to model the action of acidified water on building materials such as concrete, limestone, or marble. • chart, record, and describe evidence of chemical weathering in the local environment. • analyze and explain the difference in average winter temperatures among areas in central and western Virginia and cities and counties along the Chesapeake Bay and Atlantic coast. • explain the role of water in power generation. • describe the importance of careful management of water resources.

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		• Water is an important resource used in power generation. Hydroelectric power plants make use of the kinetic energy of water as it flows through turbines. Water is also heated in power plants and turned to steam. The steam is used to turn turbines, which generate electricity. • In the past, streams and rivers were often used to dispose of human waste, and open sewers were common. During the mid-1800s, public health officials recognized the connection between disease outbreaks and contamination of public wells and drinking water. Advances in water treatment and sanitary sewers have helped eliminate diseases associated with human waste. • Due to water's importance in power generation, agriculture, and human health, it is important to conserve water resources.	

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Time Frame	SOL Objective	Essential Understandings	Essential Knowledge/Skills
4 weeks	6.7	The concepts developed in this standard include the following: • An ecosystem is made up of the biotic (living) community and the abiotic (nonliving) factors that affect it. The health of an ecosystem is directly related to water quality. • Abiotic factors determine ecosystem type and its distribution of plants and animals as well as the usage of land by people. Abiotic factors include water supply, topography, landforms, geology, soils, sunlight, and air quality/O_2 availability. • Human activities can alter abiotic components and thus accelerate or decelerate natural processes. For example, people can affect the rate of natural erosion. Plowing cropland can cause greater erosion, while planting trees can prevent it. Flood protection/wetland loss is another example. • A watershed is the land that water flows across or through on its way to a stream, lake, wetland, or other body of water. Areas of higher elevations, such as ridgelines and divides, separate watersheds. • The three major regional watershed systems in Virginia lead to the Chesapeake Bay, the North Carolina sounds, or the Gulf of Mexico. • River systems are made up of tributaries of smaller streams that join along their courses. Rivers and streams generally have wide, flat, border areas, called flood plains, onto which water spills out at times of high flow. • Rivers and streams carry and deposit sediment. As water flow decreases in speed, the size of the sediment it carries decreases. • Wetlands form the transition zone between dry land and bodies of water such as rivers, lakes, or bays. Both tidal and nontidal wetlands perform important water quality functions, including regulating runoff by storing flood waters; reducing erosion by slowing down run-off; maintaining water quality by filtering sediments, trapping nutrients, and breaking down pollutants; and recharging groundwater. They also provide food and shelter for wildlife and fish and nesting and resting areas for migratory birds.	In order to meet this standard, it is expected that students will • comprehend and apply basic terminology related to watersheds. • use topographic maps to determine the location and size of Virginia's regional watershed systems. • locate their own local watershed and the rivers and streams associated with it. • design an investigation to model the effects of stream flow on various slopes. • analyze and explain the functioning of wetlands and appraise the value of wetlands to humans. • explain what an estuary is and why it is important to people. • propose ways to maintain water quality within a watershed. • explain the factors that affect water quality in a watershed and how those factors can affect an ecosystem. • forecast potential water-related issues that may become important in the future. • locate and critique a media article or editorial (print or electronic) concerning water use or water quality. Analyze and evaluate the science concepts involved. • argue for and against commercially developing a parcel of land containing a large wetland area. Design and defend a land-use model that minimizes negative impact. • measure, record, and analyze a variety of water quality indicators and describe what they mean to the health of an ecosystem.

		• Estuaries perform important functions, such as providing habitat for many organisms and serving as nurseries for their young. • The Chesapeake Bay is an estuary where fresh and salt water meet and are mixed by tides. It is the largest estuary in the contiguous United States and one of the most productive. • Water quality monitoring is the collection of water samples to analyze chemical and/or biological parameters. Simple parameters include pH, temperature, salinity, dissolved oxygen, turbidity, and the presence of macroinvertebrate organisms.	

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Time Frame	SOL Objective	Essential Understandings	Essential Knowledge/Skills
2 weeks	6.4	The concepts developed in this standard include the following: • The basic structural components of a typical atom are electrons, protons, and neutrons. Protons and neutrons comprise the nucleus of an atom. • An element is a form of matter made up of one type of atom. The atoms of an element are basically alike, though the number of neutrons may vary. • The atoms of one element differ from those of another element in the number of protons. • Elements can be represented by chemical symbols. • Two or more atoms of different elements may combine to form a compound. • Compounds can be represented by chemical formulas. Each different element in the compound is represented by its unique symbol. The number of each type of element in the compound (other than 1) is represented by a small number (the subscript) to the right of the element symbol. • Chemical equations can be used to model chemical changes, illustrating how elements become rearranged in a chemical reaction. • A limited number of elements, including silicon, aluminum, iron, sodium, calcium, potassium, magnesium, hydrogen, oxygen, nitrogen, and carbon, form the largest portion of Earth's crust, living matter, the oceans, and the atmosphere.	In order to meet this standard, it is expected that students will • create and interpret a simplified modern model of the structure of an atom. • compare and contrast the atomic structure of two different elements. • explain that elements are represented by symbols. • identify the name and number of each element present in a simple molecule or compound, such as O_2, H_2O, CO_2, or $CaCO_3$. • model a simple chemical change with an equation and account for all atoms. Distinguish the types of elements and number of each element in the chemical equation. (Balancing equations will be further developed in Physical Science.) • name some of the predominant elements found in the atmosphere, the oceans, living matter, and Earth's crust.

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Time Frame	SOL Objective	Essential Understandings	Essential Knowledge/Skills
3 weeks	6.8	The concepts developed in this standard include the following: • The solar system consists of the sun, moon, Earth, other planets and their moons, meteors, asteroids, and comets. Each body has its own characteristics and features. • The distance between planets and sizes of the planets vary greatly. The outer, "gas" planets are very large, and the four inner planets are comparatively small and rocky. • Gravity is a force that keeps the planets in motion around the sun. Gravity acts everywhere in the universe. • Planets revolve around the sun, and moons revolve around planets. A planet rotates upon an axis. • A dwarf planet revolves around the sun, and can maintain a nearly round shape as planets do, but it cannot move other objects away from its orbital neighborhood. • As Earth rotates, different sides of Earth face toward or away from the sun, thus causing day and night, respectively. • The phases of the moon are caused by its position relative to Earth and the sun. • Earth is a rocky planet, extensively covered with large oceans of liquid water and having frozen ice caps in its polar regions. Earth has a protective atmosphere consisting predominantly of nitrogen and oxygen and has a magnetic field. The atmosphere and the magnetic field help shield Earth's surface from harmful solar radiation. Scientific evidence indicates that Earth is about 4.5 billion years old. • Seasons are caused by a combination of the tilt of Earth on its axis, the curvature of Earth's surface and, thus, the angle at which sunlight strikes the surface of Earth during its annual revolution around the sun. • Tides are the result of the gravitational pull of the moon and sun on the surface waters of Earth. • The ideas of Ptolemy, Aristotle, Copernicus, and Galileo contributed to the development of our understanding of the solar system.	In order to meet this standard, it is expected that students will • describe the planets and their relative positions from the sun. • compare the characteristics of Pluto to the planets and explain its designation as a dwarf planet. • design and interpret a scale model of the solar system. (A scale model may be a physical representation of an object or concept. It can also be a mathematical representation that uses factors such as ratios, proportions, and percentages.) • explain the role of gravity in the solar system. • compare and contrast revolution and rotation and apply these terms to the relative movements of planets and their moons. • model and describe how day and night and the phases of the moon occur. • model and describe how Earth's axial tilt and its annual orbit around the sun cause the seasons. • describe the unique characteristics of planet Earth. • discuss the relationship between the gravitational pull of the moon and the cycle of tides. • compare and contrast the ideas of Ptolemy, Aristotle, Copernicus, and Galileo related to the solar system. • create and interpret a timeline highlighting the advancements in solar system exploration over the past half century. This should include information on the first modern rockets, artificial satellites, orbital missions, missions to the moon, Mars robotic explorers, and exploration of the outer planets.

		• With the development of new technology over the last half-century, our knowledge of the solar system has increased substantially.	

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Time Frame	SOL Objective	Essential Understandings	Essential Knowledge/Skills
3 weeks	6.3	The concepts developed in this standard include the following: • Earth receives only a very small portion of the sun's energy, yet this energy is responsible for powering the motion of the atmosphere, the oceans, and many processes at Earth's surface. • Solar radiation is made up of different types of radiation (including infrared, visible light, and ultraviolet). • Incoming solar radiation is in close balance with the energy that leaves the atmosphere; otherwise Earth would heat up or cool down. Excess carbon dioxide and other gases may disrupt this balance, creating a greenhouse effect. • About one-third of the sun's incoming energy is reflected back out to space. About one-half of the energy striking Earth is absorbed by Earth's surface. • Earth's surface is heated unequally. • When air or water is heated, the molecules move faster and farther apart, reducing their density and causing them to rise. Cooler air or water molecules move more slowly and are denser than warm air or water. Warm air or water rising coupled with cooler air or water descending forms a cyclic rising/falling pattern called convection. • Radiation and convection from Earth's surface transfer thermal energy. This energy powers the global circulation of the atmosphere and the oceans on our planet. • As bodies of water (oceans, lakes, rivers, etc.) absorb thermal energy, the water evaporates causing the air to be warm and moist. Warm, moist air is less dense than cold, dry air, so it rises relative to colder, drier air. As warm, moist air rises, it gives off some thermal energy as the moisture condenses, forming clouds. Clouds are not gaseous water vapor; rather they are minute, condensed water particles. • Some thunderstorms are formed where the land is strongly heated. Hurricanes form over warm, tropical water and are fed by the energy of that water. •	In order to meet this standard, it is expected that students will • comprehend and apply basic terminology related to solar energy, including wavelength; ultraviolet, visible, and infrared radiation; and reflection and absorption. • analyze and interpret a chart or diagram showing Earth's energy budget. • analyze, model, and explain the greenhouse effect in terms of the energy entering and leaving the atmosphere. • design an investigation to determine the effect of sunlight on the heating of a surface. • analyze and explain how convection currents occur and how they distribute thermal energy in the atmosphere and oceans. • analyze the role of heating and cooling in the formation of clouds. • order the sequence of events that takes place in the formation of a cloud. describe the relationship between thermal energy and the formation of hurricanes and thunderstorms.

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Time Frame	SOL Objective	Essential Understandings	Essential Knowledge/Skills
2 weeks	6.2	The concepts developed in this standard include the following: • Potential energy is energy that is not "in use" and available to do work. Kinetic energy is energy that is "in use" — the energy a moving object has due to its motion. For example, moving water and wind have kinetic energy. The chemical energy in fossil fuels is potential energy until it is released. • Solar energy from the ancient past is stored in fossil fuels, such as coal, petroleum, and natural gas. Fossil fuels are rich in the elements carbon and hydrogen. These sources of energy take very long periods of time to form and once depleted, are essentially nonrenewable. Nuclear power is also a source of nonrenewable energy. • Many of Earth's energy resources are available on a perpetual basis. These include solar, wind, water (hydropower, tidal and waves), biofuels and geothermal energy. Some energy sources can be replenished over relatively short periods of time. These include wood and other biomass. All are considered renewable. • Secondary sources of energy, such as electricity, are used to store, move, and deliver energy easily in usable form. Hydrogen is also a secondary source of energy, also called an energy carrier. • Thermal and radiant energy can be converted into mechanical energy, chemical energy, and electrical energy and back again.	In order to meet this standard, it is expected that students will • compare and contrast potential and kinetic energy through common examples found in the natural environment. • analyze and describe the transformations of energy involved with the formation and burning of coal and other fossil fuels. • compare and contrast renewable (solar, wind, water [hydropower, tidal and waves], biofuels, geothermal, and biomass) and nonrenewable energy sources (coal, petroleum, natural gas, nuclear power). • explain that hydrogen is not an energy source, but a means of storing and transporting energy. • design an application of the use of solar and wind energy. • chart and analyze the energy a person uses during a 24-hour period and determine the sources. • compare and contrast energy sources in terms of their origins, how they are utilized, and their availability. • analyze the advantages and disadvantages of using various energy sources and their impact on climate and the environment. • analyze and describe how the United States' energy use has changed over time. • analyze and describe sources of energy used in Virginia related to energy use nationally and globally. • predict the impact of unanticipated energy shortages. • comprehend and apply basic terminology related to energy

			sources and transformations. • create and interpret a model or diagram of an energy transformation. • design an investigation that demonstrates how light energy (radiant energy) can be transformed into other forms of energy (mechanical, chemical and electrical).

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Time Frame	SOL Objective	Essential Understandings	Essential Knowledge/Skills
On-going	6.9	The concepts developed in this standard include the following: • People, as well as other living organisms, are dependent upon the availability of clean water and air and a healthy environment. • Local, state, and federal governments have significant roles in managing and protecting air, water, plant, and wildlife resources. • Modern industrial society is dependent upon energy. Fossil fuels are the major sources of energy in developed and industrialized nations and should be managed to minimize adverse impacts. • Many renewable and nonrenewable resources are managed by the private sector (private individuals and corporations). • Renewable resources should be managed so that they produce continuously. Sustainable development makes decisions about long-term use of the land and natural resources for maximum community benefit for the longest time and with the least environmental damage. • Regulations, incentives, and voluntary efforts help conserve resources and protect environmental quality. • Conservation of resources and environmental protection begin with individual acts of stewardship. • Use of renewable (water, air, soil, plant life, animal life) and nonrenewable resources (coal, oil, natural gas, nuclear power, and mineral resources) must be considered in terms of their cost/benefit tradeoffs. • Preventive measures, such as pollution prevention or thoughtfully planned and enforced land-use restrictions, can reduce the impact of potential problems in the future. • Pollution prevention and waste management are less costly than cleanup.	In order to meet this standard, it is expected that students will • differentiate between renewable and nonrenewable resources. • describe the role of local and state conservation professionals in managing natural resources. These include wildlife protection; forestry and waste management; and air, water, and soil conservation. • analyze resource-use options in everyday activities and determine how personal choices have costs and benefits related to the generation of waste. • analyze how renewable and nonrenewable resources are used and managed within the home, school, and community. • analyze reports, media articles, and other narrative materials related to waste management and resource use to determine various perspectives concerning the costs/benefits in real-life situations. • evaluate the impact of resource use, waste management, and pollution prevention in the school and home environment.