Attachment B

Science Standards of Learning

for Virginia Public Schools

Board of Education
Commonwealth of Virginia

~~January 2010~~Anticipated October 2018

Science Standards of Learning

for Virginia Public Schools

Adopted in ~~January 2010~~Anticipated October 2018 by the
Board of Education
~~Mark E. Emblidge, President~~Daniel A. Gecker, President
~~Ella P. Ward, Vice President~~
Diane T. Atkinson, Vice President
~~Thomas M. Brewster~~
Kim E. Adkins
~~Billy K. Cannaday~~
James H. Dillard
~~Isis M. Castro~~
Anne B. Holton
~~David L. Johnson~~
Elizabeth Vickrey Lodal
~~K. Rob Krupicka~~
Sal Romero, Jr.

~~Virginia L. McLaughlin~~Tamara K. Wallace

~~Eleanor B. Saslaw~~Jamelle S. Wilson

Superintendent of Public Instruction
~~Patricia I. Wright~~James F. Lane

Commonwealth of Virginia
Board of Education
Post Office Box 2120

Richmond, VA 23218-2120

Superintendent of Public Instruction
~~Patricia I. Wright~~ James F. Lane

Assistant Superintendent for Instruction
~~Linda M. Wallinger~~ Steven M. Constantino

Office of Science, Technology, Engineering, and Mathematics ~~Middle and High School Instructional Services~~
~~Paula J. Klonowski, Science Coordinator~~
Tina Manglicmot, Director
Anne Petersen, Science Coordinator
Laura Casdorph, Science Specialist
Myra Thayer, Science Specialist
~~Office of Elementary Instructional Services~~
~~Mark R. Allan, Director~~
~~Barbara P. Young, Science Specialist~~

Notice to Reader

~~The Virginia Department of Education does not unlawfully discriminate on the basis of race, color, sex, national origin, age, or disability in employment or in its educational programs or services~~.
The Virginia Department of Education does not discriminate on the basis of race, sex, color, national origin, religion, sexual orientation, gender identity, age, political affiliation, or against otherwise qualified persons with disabilities.

Preface

In 1995, the Virginia Board of Education published Standards of Learning in English, mathematics, science, and history and social science for kindergarten through grade 12. Subsequently, Standards of Learning were developed for all academic content areas. The Standards of Learning provide a framework for instructional programs designed to raise the academic achievement of all students in Virginia, and to prepare students for post-secondary success. School divisions and teachers incorporate the standards in local curriculum and classroom instruction.

~~The Standards of Learning in this publication represent a significant development in public education in Virginia. These standards focus on the scientific knowledge and skills all students need for the future, and they have been aligned with national expectations for postsecondary success.~~

~~The Standards of Learning provide a framework for instructional programs designed to raise the academic achievement of all students in Virginia and are an important part of Virginia's efforts to provide challenging educational programs in the public schools.~~

The Standards of Learning set reasonable targets and expectations for what teachers must teach and students must learn. The standards are not intended to encompass the entire curriculum for a given grade level or course or to prescribe how the content should be taught; the standards are to be incorporated into a broader, locally designed curriculum. Teachers are encouraged to go beyond the standards and select instructional strategies and assessment methods appropriate for their students.

The Standards of Learning ~~are recognized as a model for other states. They~~ were developed through a series of public hearings and the efforts of parents, teachers, representatives from higher education, science education organizations, and business and industry leaders. The standards set clear and~~,~~ concise~~, and measurable~~ academic expectations for young people. Parents are encouraged to work with their children to help them achieve these academic standards.

Introduction

The *Science Standards of Learning* for Virginia Public Schools identify academic content for essential components of the science curriculum at different grade levels. The content of the standards, in conjunction with effective instruction, provide a platform for creating scientifically literate students. The *Science Standards of Learning* reflect a vertical progression of content and practices. ~~Standards are identified for kindergarten through grade five, for middle school, and for a core set of high school courses — Earth Science, Biology, Chemistry, and Physics. Throughout a student's science schooling from kindergarten through grade six, content strands, or topics are included.~~ The Standards of Learning contain content ~~in each~~ strands or topics that progress in complexity as they are studied at various grade levels in grades K-5~~6~~, and are represented indirectly throughout the middle and high school courses. These strands are

- Scientific Skills and Processes~~Investigation, Reasoning, and Logic;~~
- Force, Motion, and Energy~~;~~
- Matter~~;~~
- ~~Life Processes;~~
- Living Systems and Processes~~;~~
- ~~Interrelationships in~~ Earth and ~~/~~Space Systems~~;~~
- ~~Earth Patterns, Cycles, and Change; and~~
- Earth Resources~~.~~

Five key components of the science standards that are critical to implementation and necessary for student success in achieving science literacy are 1) Goals; 2) Investigate and Understand~~K-12 Safety~~; 3) Nature of Science~~Instructional Technology~~; 4) K-12 Safety ~~Investigate and Understand~~; and 5) ~~-~~Instructional Technology~~Application~~. These five components support the Virginia Profile of a Graduate and an integrated instruction approach that incorporates Science, Technology, Engineering, and Mathematics (STEM). It is imperative to science instruction that the local curriculum consider and address how these components are incorporated in the design of the kindergarten through high school science program.

Goals

The *Science Standards of Learning* for Virginia Public Schools serve as a framework for educators to meet science education goals and support students' investigation of the natural world. The goals of science instruction include

- use scientific processes to safely investigate the natural world;
- develop the scientific knowledge, skills, and attributes to be successful in college, explore science-related careers and interests, and be work-force ready ;
- develop scientific dispositions and habits of mind (collaboration, curiosity, creativity, demand for verification, open mindedness, respect for logic and rational thinking, objectivity, learning from mistakes, patience, and persistence);
- possess significant knowledge of science to be informed consumers with the ability to communicate and use science in their everyday lives and engage in public discussions;
- make informed decisions regarding contemporary civic, environmental, and economic issues; and

- develop an understanding of the interrelationship of science with technology, engineering and mathematics (STEM).

~~The purposes of scientific investigation and discovery are to satisfy humankind's quest for knowledge and understanding and to preserve and enhance the quality of the human experience. Therefore, as a result of science instruction, students will be able to achieve the following objectives:~~

~~a) Develop and use an experimental design in scientific inquiry.~~
~~b) Use the language of science to communicate understanding.~~
~~c) Investigate phenomena using technology.~~
~~d) Apply scientific concepts, skills, and processes to everyday experiences.~~
~~e) Experience the richness and excitement of scientific discovery of the natural world through the collaborative quest for knowledge and understanding.~~
~~f) Make informed decisions regarding contemporary issues, taking into account the following:~~
~~a) public policy and legislation;~~
~~b) economic costs/benefits;~~
~~c) validation from scientific data and the use of scientific reasoning and logic;~~
~~d) respect for living things;~~
~~e) personal responsibility; and~~
~~f) history of scientific discovery.~~
~~g) Develop scientific dispositions and habits of mind including:~~
~~• curiosity;~~
~~• demand for verification;~~
~~• respect for logic and rational thinking;~~
~~• consideration of premises and consequences;~~
~~• respect for historical contributions;~~
~~• attention to accuracy and precision; and~~
~~• patience and persistence.~~
~~h) Develop an understanding of the interrelationship of science with technology, engineering and mathematics.~~
~~i) Explore science-related careers and interests.~~

Investigate and Understand

Many of the standards in the *Science Standards of Learning* begin with the phrase "Students will investigate and understand." This phrase ~~was chosen to~~ communicate~~s~~ the wide range of ~~rigorous~~ science ~~skills and~~ knowledge, skills, and practices required to effectively investigate and understand the natural world~~levels embedded in each standard~~. ~~Limiting a standard to one~~

~~observable behavior, such as "describe" or "explain," would have narrowed the interpretation of what was intended to be a rich, highly rigorous, and inclusive content standard.~~

"Investigate" refers to scientific methodology and implies systematic use of the following inquiry skills:

- Asking questions and defining problems
- Planning and carrying out investigations
- Interpreting, analyzing, and evaluating data
- Constructing and critiquing conclusions and explanations
- Developing and using models
- Obtaining, evaluating, and communicating information
- ~~observing;~~
- ~~classifying and sequencing;~~
- ~~communicating;~~
- ~~measuring;~~
- ~~predicting;~~
- ~~hypothesizing;~~
- ~~inferring;~~
- ~~defining, controlling, and manipulating variables in experimentation;~~
- ~~designing, constructing, and interpreting models; and~~

~~a) interpreting, analyzing, and evaluating data.~~

"Understand" refers to the application of scientific knowledge including ~~various levels of knowledge application. In the *Science Standards of Learning*, these knowledge levels~~ include the ability to:

- apply understanding of key science concepts and the nature of science;
- use important information, key definitions, terminology, and facts to make judgments about information in terms of its accuracy, precision, consistency, or effectiveness;
- apply information and principles to new problems or situations, recognizing what information is required for a particular situation, using the information to explain new phenomena, and determining when there are exceptions;
- explain the information in one's own words, comprehend how the information is related to other key facts, and suggest additional interpretations of its meaning or importance;
- think critically, problem-solve, and make decisions;
- analyze the underlying details of important facts and principles, recognizing the key relations and patterns that are not always readily visible; and
- arrange and combine important facts, principles, and other information to produce a new idea, plan, procedure, or product to synthesize new understandings.
- ~~recall or recognize important information, key definitions, terminology, and facts;~~
- ~~explain the information in one's own words, comprehend how the information is related to other key facts, and suggest additional interpretations of its meaning or importance;~~

- ~~apply the facts and principles to new problems or situations, recognizing what information is required for a particular situation, using the information to explain new phenomena, and determining when there are exceptions;~~
- ~~analyze the underlying details of important facts and principles, recognizing the key relations and patterns that are not always readily visible;~~
- ~~arrange and combine important facts, principles, and other information to produce a new idea, plan, procedure, or product; and~~
- ~~make judgments about information in terms of its accuracy, precision, consistency, or effectiveness.~~

Therefore, the use of "investigate and understand" allows each content standard to become the basis for a broad range of teaching objectives, which the school division will develop and refine to meet the intent of the *Science Standards of Learning*.

Nature of Science

Science is not a mere accumulation of facts; instead, it is a discipline with common practices for understanding the natural world. The nature of science describes these common practices employed by scientists and it reflects the intrinsic values and assumptions of scientific knowledge. The nature of science explains the functioning of science, what science is, how it develops and builds the knowledge it generates, and the methodology used to disseminate and validate knowledge.

Regardless of the career that a student chooses to pursue, all students should be science literate with an understanding of the nature of science and the scientific knowledge and skills necessary to make informed decisions.

K-12 Safety

In implementing the *Science Standards of Learning*, teachers must be certain that students know how to follow safety guidelines, demonstrate appropriate laboratory safety techniques, and use equipment safely while working individually and in groups.

Safety must be given the highest priority in implementing the K-12 instructional program for science. Correct and safe techniques, as well as wise selection of experiments, resources, materials, and field experiences appropriate to age levels, must be carefully considered with regard to the safety precautions for every instructional activity. Safe science classrooms require thorough planning, careful management, and constant monitoring of student activities. Class enrollment should not exceed the designed capacity of the room.

Teachers must be knowledgeable of the properties, use, and proper disposal of all chemicals that may be judged as hazardous prior to their use in an instructional activity. Such information is referenced through ~~Materials~~ Safety Data Sheets (~~M~~SDS), which conform to the requirements of the Globally Harmonized System of Classification and Labeling of Chemicals (GHS), effective

May 2012. The identified precautions involving the use of goggles, gloves, aprons, and fume hoods must be followed as prescribed.

~~While no comprehensive list exists to cover all situations, the following should be reviewed to avoid potential safety problems. Appropriate safety procedures should be used in the following situations:~~

- ~~observing wildlife; handling living and preserved organisms; and coming in contact with natural hazards, such as poison ivy, ticks, mushrooms, insects, spiders, and snakes;~~
- ~~engaging in field activities in, near, or over bodies of water;~~
- ~~handling glass tubing and other glassware, sharp objects, and labware;~~
- ~~handling natural gas burners, Bunsen burners, and other sources of flame/heat;~~
- ~~working in or with direct sunlight (sunburn and eye damage);~~
- ~~using extreme temperatures and cryogenic materials;~~
- ~~handling hazardous chemicals including toxins, carcinogens, and flammable and explosive materials;~~
- ~~producing acid/base neutralization reactions/dilutions;~~
- ~~producing toxic gases;~~
- ~~generating/working with high pressures;~~
- ~~working with biological cultures including their appropriate disposal and recombinant DNA;~~
- ~~handling power equipment/motors;~~
- ~~working with high voltage/exposed wiring; and~~
- ~~working with laser beam, UV, and other radiation.~~

~~The use of human body fluids or tissues is generally prohibited for classroom lab activities. Further guidance from~~ Tthe following sources offer further guidance on science safety~~may be referenced~~:

- ~~OSHA (~~Occupational Safety and Health Administration~~)~~;
- ~~ISEF (~~International Science and Engineering Fair~~)~~ rules; ~~and~~
- Virginia Department of Education (VDOE) Science Safety Handbook on the VDOE Science Instruction webpage;
- American Chemical Society (ACS) resources: Safety in the Elementary Science Classroom, Chemical Safety for Teachers and their Supervisors, and Guidelines for Chemical Laboratory Safety on the ACS webpage; and
- public health departments' and school divisions' protocols and Chemical Hygiene Plans

Instructional Technology

The primary purpose of the use of instructional technology is to support effective teaching and learning. A secondary purpose is to aid in preparing students for life after their K-12 education by ensuring that they are skillful both in using current technology tools and in learning how to

use new tools that may benefit their personal and professional lives. As such, the use of current and emerging technology is essential to the K-12 science instructional program.

Effective use of instructional technology in the science classroom requires that technology is integrated throughout the curriculum; is seamless in application; and includes instrumentation oriented toward the teaching and learning of science concepts, skills, and processes. In addition to traditional instruments of science, such as microscopes, lab ware, and data-collecting apparatus, the technology utilized should also include computers, robotics, video-microscopes, graphing calculators, probeware, geospatial technologies, online communication, software, appropriate hardware, as well as other applicable emerging technologies.

~~The use of current and emerging technologies is essential to the K-12 science instructional program. Specifically, technology must accomplish the following:~~

- ~~Assist in improving every student's functional literacy. This includes improved communication through reading/information retrieval (the use of telecommunications), writing (word processing), organization and analysis of data (databases, spreadsheets, and graphics programs), presentation of one's ideas (presentation software), and resource management (project management software).~~
- ~~Be readily available and regularly used as an integral and ongoing part of the delivery and assessment of instruction.~~
- ~~Include instrumentation oriented toward the instruction and learning of science concepts, skills, and processes. Technology, however, should not be limited to traditional instruments of science, such as microscopes, labware, and data-collecting apparatus, but should also include computers, robotics, video-microscopes, graphing calculators, probeware, geospatial technologies, online communication, software and appropriate hardware, as well as other emerging technologies.~~
    - ~~a) Be reflected in the "instructional strategies" generally developed at the school division level.~~

~~In most cases, the application of technology in science should remain "transparent" unless it is the actual focus of the instruction. One must expect students to "do as a scientist does" and not simply hear about science if they are truly expected to explore, explain, and apply scientific concepts, skills, and processes.~~

~~As computer/technology skills are essential components of every student's education, it is important that teaching these skills is a shared responsibility of teachers of all disciplines and grade levels.~~

~~Application~~

~~Science provides the key to understanding the natural world. The application of science to relevant topics provides a context for students to build their knowledge and make connections across content and subject areas. This includes applications of science among technology, engineering, and mathematics, as well as within other science disciplines. Various strategies can be used to facilitate these applications and to promote a better understanding of the interrelated nature of these four areas.~~

Profile of a Graduate

The *2018 Science Standards of Learning* support the Virginia Profile of a Graduate through the development and use of communication, collaboration, critical and creative thinking skills and the applications of civic responsibility in both the understanding and applications of science.

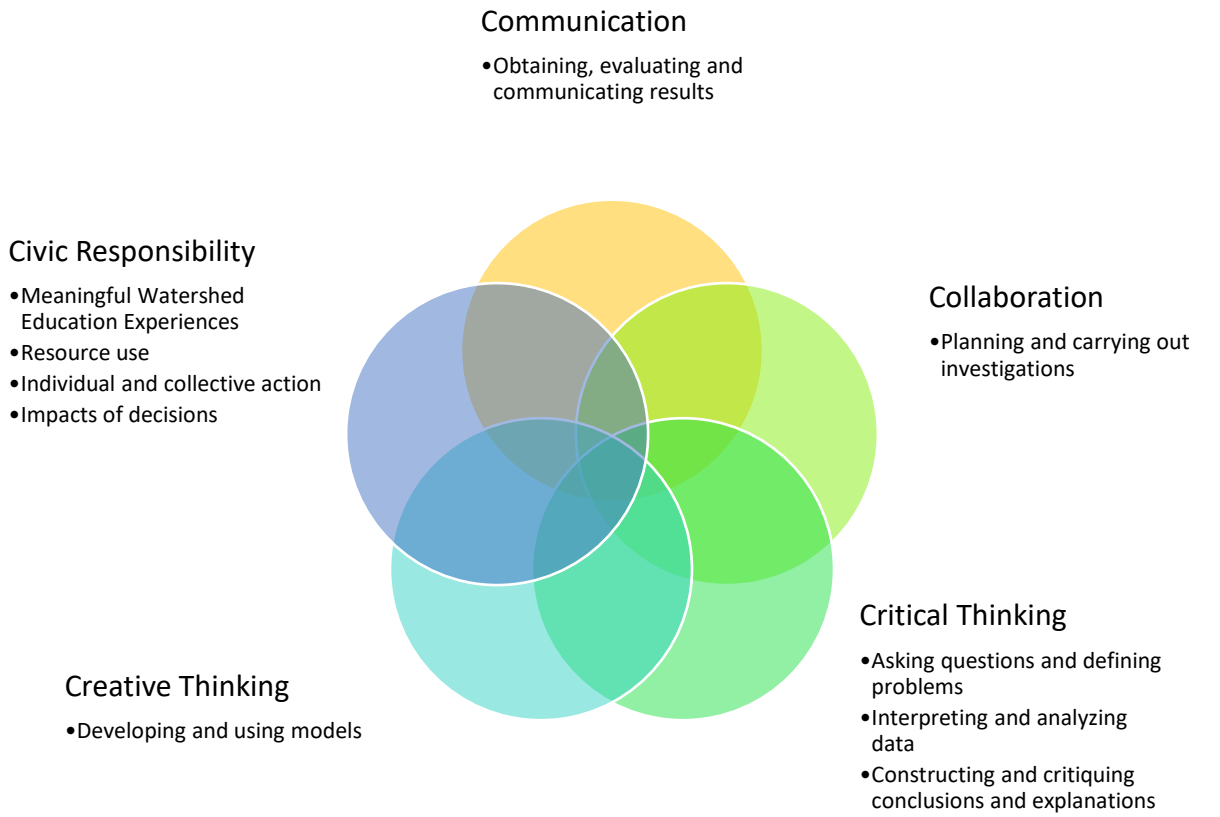

Figure 1: Visual representation of the science skills and processes aligned to the Virginia Profile of a Graduate

Kindergarten

Using my senses to understand my world

In science, Kindergarten students use their senses to make observations of the characteristics and interactions of objects in their world. Students study the characteristics of water and the basic needs of living things. They also study the relationship between the Sun and Earth through shadows and weather. They determine how their actions can change the motion of objects and learn how they can make a difference in their world. Throughout the elementary years, students will develop scientific skills, supported by mathematics and computational thinking, as they learn science content. In kindergarten, students will develop skills in posing simple questions, conducting simple investigations, observing, classifying, and communicating information about the natural world.

~~The kindergarten standards stress the use of basic science skills to explore common materials, objects, and living things and will begin the development of an understanding that scientific knowledge is based on evidence. Emphasis is placed on using the senses to gather information. Students are expected to develop skills in posing simple questions, measuring, sorting, classifying, and communicating information about the natural world. The science skills are an important focus as students learn about life processes and properties of familiar materials, such as magnets and water. Through phenomena including shadows, patterns of weather, and plant growth, students are introduced to the concept of change. The significance of natural resources and conservation is introduced in the kindergarten standards.~~

Scientific Skills and Processes~~Investigation, Reasoning, and Logic~~

K.1 The student will demonstrate an understanding of scientific skills and processes by ~~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.~~

a) asking questions and defining problems
- ask questions based on observations
- 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

e) developing and using models
- distinguish between a model and an actual object

f) obtaining, evaluating, and communicating information
- communicate comparative measures (e.g., heavier, lighter, longer, shorter, more, less, hotter, colder)
- communicate observations using pictures, drawings, and/or speech

~~K.2 The student will investigate and understand that humans have senses that allow them to seek, find, take in, and 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.~~

Force, Motion, and Energy

K.2~~3~~ The student will investigate and understand that pushes and pulls affect the motion of objects.~~magnets have an effect on some materials, make some things move without touching them, and have useful applications.~~ Key ideas ~~concepts~~ include

~~a) magnetism and its effects; and~~

~~b) useful applications of magnetism.~~

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.

Matter

K.3.4 The student will investigate and understand that ~~the position, motion, and~~ physical properties of an object can be described. Properties ~~Key concepts~~ include
a) colors ~~of objects~~;
b) shapes and forms ~~of objects~~;
c) textures and feel ~~of objects~~; and
d) relative sizes and weights of objects~~; . and~~
~~a) relative positions and speed of objects.~~

K.45 The student will investigate and understand that water is important in our daily lives ~~flows~~ and has properties~~. that can be observed and tested~~. Key ideas ~~concepts~~ include
a) water has many uses;
b) water can be found in many places;
~~a)~~c) water occurs in different phases; and
~~b)~~d) water flows downhill.~~; and~~
~~a) some materials float in water, while others sink.~~

Living Systems and ~~Life~~ Processes

K.5 The students will investigate and understand that senses allow humans to seek, find, take in, and react or respond to different information. Key ideas include
a) the five senses correspond to specific human body structures; and
b) senses are used in our daily lives.

K.6 The student will investigate and understand that there are ~~the~~ differences between living organisms and nonliving objects. Key ideas ~~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.7 The student will investigate and understand that plants and animals have basic needs and life processes ~~of plants and animals~~. Key ideas ~~concepts~~ include
a) ~~animals~~ living things need adequate food, water, shelter, air, and space to survive;
~~b) plants need nutrients, water, air, light, and a place to grow to survive;~~
~~c)~~b) plants and animals change ~~as they grow,~~and have ~~varied~~ life cycles;~~, and eventually die;~~ and
~~d)~~c) offspring of plants and animals are similar but not identical to their parents or to one another.

~~Interrelationships in~~ Earth and ~~/~~Space Systems

K.8 The student will investigate and understand that light influences temperature on Earth's surfaces and can cause shadows.~~that shadows occur when light is blocked by an object.~~ Key ~~concepts~~ ideas include

a) the sun provides light and warms Earth's surface;

~~a)~~b) shadows can be produced ~~occur in nature~~ when sunlight or artificial light is blocked by an object; and

~~b)~~c) objects in shadows and sunlight have different temperatures. ~~can be produced by blocking artificial light sources~~

~~Earth Patterns, Cycles, and Change~~

K.9 The student will investigate and understand that there are ~~simple repeating~~ patterns in ~~-~~nature ~~his/her daily life~~. Key ~~concepts~~ patterns include

a) daily weather ~~observations~~;

b) seasonal changes; ~~the shapes and forms of many common natural objects including seeds, cones, and leaves;~~ and

c) day and night.~~animal and plant growth.~~

K.10 The student will investigate and understand that change occurs over time ~~and rates may be fast or slow~~. Key ideas ~~concepts~~ include

a) natural and human-made things ~~may~~ change over time, ~~and~~

b) living and nonliving things change over time;

~~b)~~c) changes can be observed and measured~~.~~; and

d) changes may be fast or slow.

Earth Resources

K.11 The student will investigate and understand that humans use resources. ~~materials can be reused, recycled, and conserved.~~ Key ~~concepts~~ ideas include

a) some materials and objects can be used over and over again;

b) ~~everyday~~ materials can be recycled; and

~~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.

Grade One

How I interact with my world

In first grade science, students become aware of factors that affect their daily lives. Students learn about the basic needs of all living things and that living things respond to factors in their environment, including weather and the change of season. They continue the examination of matter by observing physical properties and how materials interact with light. Throughout the elementary years, students will develop scientific skills, supported by mathematics and computational thinking, as they learn science content. In first grade, students will develop skills in posing simple questions, conducting simple investigations, observing, classifying, and communicating information about the natural world.

~~The first-grade standards continue to stress basic science skills in understanding familiar objects and events. Students are expected to begin conducting simple experiments and be responsible for some of the planning. Students are introduced to the concept of classifying plants and animals based on simple characteristics. Emphasis is placed on the relationships among objects and their interactions with one another. Students are expected to know the basic relationships between the sun and Earth, and between seasonal changes and plant and animal activities. Students will also begin to develop an understanding of moving objects, simple solutions, and important natural resources.~~

Scientific ~~Investigation, Reasoning, and Logic~~Skills and Processes

1.1 ~~1.1~~ The student will demonstrate an understanding of scientific skills and processes by

~~a) reasoning, logic, and the nature of science by planning and conducting investigations in which~~

~~b) the senses are used to observe differences in physical properties;~~

~~c) observations are made from multiple positions to achieve a variety of perspectives and are repeated to ensure accuracy;~~

~~d) objects or events are classified and arranged according to characteristics or properties;~~

~~e) simple tools are used to enhance observations;~~

~~f) length, mass, volume, and temperature are measured using nonstandard units;~~

~~g) inferences are made and conclusions are drawn about familiar objects and events;~~

~~h) a question is developed from one or more observations;~~

~~i) predictions are made based on patterns of observations;~~

~~j) observations and data are recorded, analyzed, and communicated orally and with simple graphs, pictures, written statements, and numbers; and~~

~~k) simple investigations and experiments are conducted to answer questions.~~

a) asking questions and defining problems

- ask questions and make predictions based on observations
- 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, mass, 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 *more*, *less*, *fewer*, *greater than*, *less than*, *and equal to*

d) constructing and critiquing conclusions and explanations
- make simple conclusions based on data or observations
- recognize unusual or unexpected results

e) developing and using 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

Force, Motion, and Energy

1.2 The student will investigate and understand that ~~moving~~ objects can move in different ways ~~exhibit different kinds of motion~~. Key ~~concepts~~ ideas include

~~c)~~a) objects may have straight, circular, spinning, and back-and-forth motions; and

~~d)~~b) objects may vibrate and produce sound~~; and~~.

~~a) pushes or pulls can change the movement of an object.~~

Matter

1.3 The student will investigate and understand that objects are made from materials that can be described by their physical properties. ~~how different common materials interact with water.~~ Key ~~concepts~~ ideas 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.~~

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.

Living Systems and ~~Life~~ Processes

1.4 The student will investigate and understand that plants have basic life needs and functional parts ~~that allow them to survive and can be classified according to certain characteristics~~. Key ~~concepts~~ ideas include

~~b)~~a) plants need nutrients, air, water, light, and a place to grow;

~~c)~~b) structures of plants perform specific functions ~~basic parts of plants~~; and

~~d)~~c) plants can be classified based on 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 and certain distinguishing characteristics~~. Key ideas ~~concepts~~ include

~~b)~~a) ~~basic~~ animals need~~s include adequate~~ air, food, water, shelter, and space (habitat);

~~c)~~b) animals ~~, including humans,~~ have many different physical characteristics; and

~~d)~~c) animals can be classified based ~~according~~ on ~~to~~ a variety of characteristics.

~~Interrelationships in~~ Earth~~/~~ and Space Systems

1.6 The student will investigate and understand ~~the~~ that there is a ~~basic~~ relationship ~~s~~ between the S~~s~~un and Earth. Key ideas ~~concepts~~ include

a) the S~~s~~un is the source of energy and light that warms the land, air, and water; and

b) the ~~sun's~~ Sun's relative position ~~in the morning is east and in the late afternoon is west.~~changes in the Earth's sky throughout the day.

~~Earth Patterns, Cycles, and Change~~

1.7 The student will investigate and understand that there are weather and seasonal changes. Key ideas ~~concepts~~ include

a) changes in temperature, light, and precipitation ~~affect plants and animals, including humans~~occur over time;

b) there are relationships between daily weather and the season~~s~~~~al changes~~; and

c) changes in temperature, light, and precipitation ~~can be observed and recorded over time~~affect plants and animals, including humans.

Earth Resources

1.8 The student will investigate and understand that natural resources can be used responsibly~~. are limited~~. Key ~~concepts~~ ideas include

a) ~~identification of~~ most natural resources are limited;

b) ~~factors that affect air and water quality~~human actions can impact the availability of natural resources; and

c) recycling, reusing, and reducing consumption are ways to conserve ~~of~~ natural resources.

Grade Two

Change occurs all around us

Science in second grade builds on the previous understandings of forces, water, weather, and plants and animals, and students explore these concepts through the lens of change. They examine how water changes phase, how visible and invisible forces change motion, how plants and animals change through their life cycles, and how weather changes the Earth. Students also examine how change occurs over a short or long period of time. Throughout the elementary years, students will develop scientific skills, supported by mathematics and computational thinking, as they learn science content. In second grade, students will develop skills in posing simple questions, planning and conducting simple investigations, observing, classifying, and communicating information about the natural world.

~~The second-grade standards continue to focus on using a broad range of science skills in understanding the natural world. Making detailed observations, drawing conclusions, and recognizing unusual or unexpected data are stressed as skills needed for using and validating information. Measurement in both English and metric units is stressed. The idea of living systems is introduced through habitats and the interdependence of living and nonliving things. The concept of change is explored in phases of matter, life cycles, weather patterns, and seasonal effects on plants and animals.~~

Scientific Skills and Processes~~Investigation, Reasoning, and Logic~~

2.1 ~~2.1~~ The student will demonstrate an understanding of scientific skills and processes by

~~a) reasoning, logic, and the nature of science by planning and conducting investigations in which~~

~~b) observations and predictions are made and questions are formed;~~

~~c) observations are differentiated from personal interpretation;~~

~~d) observations are repeated to ensure accuracy;~~

~~e) two or more characteristics or properties are used to classify items;~~

~~f) length, volume, mass, and temperature are measured in metric units and standard English units using the proper tools;~~

~~g) time is measured using the proper tools;~~

~~h) conditions that influence a change are identified and inferences are made;~~

~~i) data are collected and recorded, and bar graphs are constructed using numbered axes;~~

~~j) data are analyzed, and unexpected or unusual quantitative data are recognized;~~

~~k) conclusions are drawn;~~

~~l) observations and data are communicated;~~

~~m) simple physical models are designed and constructed to clarify explanations and show relationships; and~~

~~n) current applications are used to reinforce science concepts.~~

a) asking questions and defining problems

- ask questions that can be investigated
- make predictions based on observations and prior experiences

- 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, plan and conduct simple investigations to produce data
- use appropriate tools to measure length, mass, volume, and temperature of common objects using metric and U.S. Customary units
- measure time intervals using proper tools

c) interpreting, analyzing, and evaluating data
- organize and represent data in pictographs and bar graphs
- read and interpret data represented in pictographs and bar graphs

d) constructing and critiquing conclusions and explanations
- make simple conclusions based on data or observations
- distinguish between opinion and evidence
- recognize unusual or unexpected results

e) developing and using models
- 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

Force, Motion, and Energy

2.2 The student will investigate and understand that different types of forces may cause an object's motion to change. ~~natural and artificial magnets have certain characteristics and attract specific types of metals.~~ Key ideas ~~concepts~~ include

~~a) magnetism, iron, magnetic/nonmagnetic, poles, attract/repel; and~~

a) pushes and pulls from direct contact can cause an object to move;

b) indirect forces, including gravity and magnetism, can also cause objects to move; and

c) forces have applications in our lives.

~~a. important applications of magnetism.~~

Matter

2.3 The student will investigate and understand that matter can exist in different phases. ~~basic properties of solids, liquids, and gases.~~ Key ~~concepts~~ ideas include

a) ~~identification of distinguishing characteristics of~~ solids, liquids, and gases have different characteristics; and

~~b) measurement of the mass and volume of solids and liquids; and~~

~~c)~~b) ~~changes in~~heating and cooling can change the phases of matter. ~~with the addition or removal of energy.~~

Living Systems and ~~Life~~ Processes

2.4 The student will investigate and understand that plants and animals undergo a series of orderly changes as they ~~mature and~~ grow and develop. Key ~~concepts~~ ideas include

a) animals have life cycles; and
b) plants have life cycles.

~~**Living Systems**~~

2.5 The student will investigate and understand that living things are part of a system. Key ~~concepts~~ ideas include
a) ~~living~~ organisms are interdependent with their living and nonliving surroundings;
b) an animal's habitat provides all of its basic needs~~ includes adequate food, water, shelter or cover, and space~~; and
c) habitats change over time due to many influences.
~~; and~~
~~a. fossils provide information about living systems that were on Earth years ago.~~

~~**Interrelationships in** **Earth**~~ **and Space Systems**

2.6 The student will investigate and understand that there are different types of weather on Earth~~affects both living and nonliving parts of~~. ~~basic types, changes, and patterns of weather.~~ Key ideas ~~concepts~~ include
~~b)~~a) ~~identification of common storms and other weather phenomena~~ different types of weather have specific characteristics;
~~c)~~b) ~~the uses and importance of~~ measuring, recording, and interpreting weather data allows for identification of weather patterns; and
~~d)~~c) ~~the uses and importance of~~ tracking weather allows us to prepare for the weather and storms~~data over time~~.

~~**Earth Patterns, Cycles, and Change**~~

2.7 The student will investigate and understand that weather patterns and seasonal changes affect plants, animals, and their surroundings. Key ~~concepts~~ ideas include
a) ~~effects of~~ weather and seasonal changes ~~on~~ affect the growth and behavior of living things; ~~and~~
b) wind and weather can change the land of the land; and~~weathering and erosion of land surfaces.~~
c) changes can happen quickly or slowly over time.

Earth Resources

2.8 The student will investigate and understand that plants are important natural resources~~ produce oxygen and food, are a source of useful products, and provide benefits in nature~~. Key ~~concepts~~ ideas include
~~a) important plant products are identified and classified;~~
~~b)~~a) the availability of plant products affects the development of a geographic area;
~~c)~~b) plants provide oxygen, homes, and food for many animals; and
~~d)~~c) plants can help reduce ~~erosion~~the impact of wind and water.

Grade Three

~~The third-grade standards place increasing emphasis on conducting investigations. Students are expected to be able to develop questions, formulate simple hypotheses, make predictions, gather data, and use the metric system with greater precision. Using information to make inferences and draw conclusions becomes more important. In the area of physical science, the standards focus on simple and compound machines, energy, and a basic understanding of matter. Behavioral and physical adaptations are examined in relation to the life needs of animals. The notion of living systems is further explored in aquatic and terrestrial food chains and diversity in ecosystems. Patterns in the natural world are demonstrated in terms of the phases of the moon, tides, seasonal changes, the water cycle, and animal and plant life cycles. Geological concepts are introduced through the investigation of the components of soil.~~

Interactions in our world

The focus of science in third grade is interactions in our world. Students continue their study of forces by learning about simple machines and they examine the interactions of materials in water. They also look at how plants and animals, including humans, are constantly interacting with both the living and nonliving aspects of the environment. This includes how adaptations satisfy the life needs of plants and animals and the importance of water, soil, and the Sun in the survival of plants and animals. Throughout the elementary years, students will develop scientific skills, supported by mathematics and computational thinking, as they learn science content. In third grade, students will develop skills in posing questions and predicting outcomes, planning and conducting simple investigations, collecting and analyzing data, constructing explanations, and communicating information about the natural world.

Scientific Skills and Processes~~Investigation, Reasoning, and Logic~~

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

- ~~observations are made and are repeated to ensure accuracy;~~
- ~~predictions are formulated using a variety of sources of information;~~
- ~~objects with similar characteristics or properties are classified into at least two sets and two subsets;~~
- ~~natural events are sequenced chronologically;~~
- ~~length, volume, mass, and temperature are estimated and measured in metric and standard English units using proper tools and techniques;~~
- ~~time is measured to the nearest minute using proper tools and techniques;~~
- ~~questions are developed to formulate hypotheses;~~
- ~~data are gathered, charted, graphed, and analyzed;~~
- ~~unexpected or unusual quantitative data are recognized;~~
- ~~inferences are made and conclusions are drawn;~~
- ~~data are communicated;~~
- ~~models are designed and built; and~~

- ~~current applications are used to reinforce science concepts.~~

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 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

d) constructing and critiquing conclusions and explanations
   - 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 grade-level appropriate texts and/or other reliable media
   - communicate scientific information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts
   - communicate design ideas and/or solutions with others

Force, Motion, and Energy

3.2 The student will investigate and understand that the direction and size of force affects the motion of an object~~simple machines and their uses~~. Key ideas ~~concepts~~ include

a) multiple forces may act on an object~~purpose and function of simple machines~~;
b) the net force on an object determines how an object moves~~types of simple machines~~;

c) simple machines increase or change the direction of a force~~compound machines~~; and
d) ~~examples of~~ simple and compound machines have many applications~~found in the school, home, and work environments~~.

Matter

3.3 The student will investigate and understand how materials interact with water. ~~that objects are made of materials that can be described by their physical properties.~~ Key ideas ~~concepts~~ include
a) some liquids mix with water~~objects are made of one or more materials~~;
b) some solids dissolve in water~~physical properties remain the same as the material is changed in visible size~~; and
c) many solids dissolve more easily in hot water than in cold water~~visible physical changes are identified~~.

Livingfe Systems and Processes

3.4 The student will investigate and understand that adaptations allow animals to satisfy life needs and respond to the environment. Key ideas ~~concepts~~ include
a) populations may adapt over time~~behavioral adaptations~~; ~~and~~
b) ~~physical~~ adaptations~~.~~ may be behavioral or physical; and
c) fossils provide evidence about the types of organisms that lived long ago as well as the nature of their environments.

~~**Living Systems**~~

3.5 The student will investigate and understand that ~~relationships among organisms in~~ aquatic and terrestrial ~~ecosystems support a diversity of plants and animals~~~~food chains~~. Key ideas ~~concepts~~ include
a) ecosystems are made of living and nonliving components of the environment~~producer, consumer, decomposer~~; and
b) relationships exist among organisms in an ecosystem. ~~herbivore, carnivore, omnivore; and~~
~~a) predator and prey.~~

~~3.6 The student will investigate and understand that ecosystems support a diversity of plants and animals that share limited resources. Key concepts include~~
~~1. aquatic ecosystems;~~
~~2. terrestrial ecosystems;~~
~~3. populations and communities; and~~
~~4. the human role in conserving limited resources.~~

~~**Interrelationships in**~~ **Earth and ~~/~~Space Systems**

3.~~7~~6 The student will investigate and understand ~~the~~ that ~~major components of~~ soil is important in ecosystems.~~,~~ ~~its origin, and its importance to plants and animals including humans.~~ Key ideas ~~concepts~~ include

a) soil, with its different components, is important to ~~provides the support and nutrients necessary for~~ plants and animals; ~~growth;~~ and
b) ~~topsoil is a natural product of subsoil and bedrock;~~ soil provides support and nutrients necessary for plant growth.

~~a) rock, clay, silt, sand, and humus are components of soils; and~~
~~b) soil is a natural resource and should be conserved.~~

~~**Earth Patterns, Cycles, and Change**~~

~~3.8 The student will investigate and understand basic patterns and cycles occurring in nature. Key concepts include~~
~~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~~7 The student will investigate and understand that there is a ~~the~~ water cycle and water is important ~~its relationship~~ to life on Earth. Key ideas ~~concepts~~ include
~~b)~~a) there are many ~~sources~~ reservoirs of water on Earth;
~~c)~~b) the energy from the ~~sun~~ Sun drives the water cycle;
~~d)~~c) the water cycle involves specific ~~several~~ processes; and
~~e)~~d) water is essential for living things~~; .and~~

~~a) water on Earth is limited and needs to be conserved.~~

Earth Resources

3.~~8~~10 The student will investigate and understand that natural events and humans impact ecosystems ~~influences can affect the survival of species~~. Key ~~concepts~~ ideas include
a) human activity has an effect on the quality of air, water, and habitat~~the interdependency of plants and animals~~;
b) water is limited and needs to be conserved~~the effects of human activity on the quality of air, water, and habitat~~;
c) ~~the effects of~~ fire, flood, disease, and erosion affect ~~on~~ ecosystems~~organisms~~; and
d) soil is a natural resource and should be conserved~~conservation and resource renewal~~.

~~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.~~

Grade Four

~~The fourth-grade standards stress the importance of using information, analyzing data, and validating experimental results. Defining variables in experimentation is emphasized, and making simple predictions from picture, bar, and basic line graphs is underscored. Questioning and hypothesizing become more detailed at this level. Students are introduced to basic principles of electricity and to the concept of motion. Students explore basic information about our solar system and investigate the interactions among Earth, the moon, and the sun. Students explore basic plant anatomy, plant adaptations, and investigate relationships among plants and animals and their environments. In examining weather phenomena and conditions, students identify various factors, make predictions based on data, and evaluate the results. The importance of natural resources in Virginia is emphasized.~~

Our place in the universe

Our universe is a grand place, and in fourth grade science, students learn where we fit in this universe. Starting with the solar system, and then moving to the planet Earth, the Commonwealth of Virginia, and finally their specific ecosystems, students examine how features of plants and animals support life. They also explore how living things interact with both living and nonliving components in their ecosystems. Throughout the elementary years, students will develop scientific skills, supported by mathematics and computational thinking, as they learn science content. In fourth grade, students will develop skills in posing questions and predicting outcomes, planning and conducting simple investigations, collecting and analyzing data, constructing explanations, and communicating information about the natural world.

Scientific Skills and Processes~~Investigation, Reasoning, and Logic~~

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

~~a) distinctions are made among observations, conclusions, inferences, and predictions;~~

~~b) objects or events are classified and arranged according to characteristics or properties;~~

~~c) appropriate instruments are selected and used to measure length, mass, volume, and temperature in metric units;~~

~~d) appropriate instruments are selected and used to measure elapsed time;~~

~~e) predictions and inferences are made, and conclusions are drawn based on data from a variety of sources;~~

~~f) independent and dependent variables are identified;~~

~~g) constants in an experimental situation are identified;~~

~~h) hypotheses are developed as cause and effect relationships;~~

~~i) data are collected, recorded, analyzed, and displayed using bar and basic line graphs;~~

~~j) numerical data that are contradictory or unusual in experimental results are recognized;~~

~~k) data are communicated with simple graphs, pictures, written statements, and numbers;~~
~~l) models are constructed to clarify explanations, demonstrate relationships, and solve needs; and~~
~~m) current applications are used to reinforce science concepts.~~

a) asking questions and defining problems
- identify scientific and non-scientific questions
- develop hypotheses as cause and effect relationships

b) planning and carrying out investigations
- identify variables when planning an investigation
- collaboratively plan and conduct investigations
- make metric measurements using appropriate tools

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 bar graph, a chart and a line graph, or a pictograph and a bar graph)
- classify organisms based on characteristics

d) constructing and critiquing conclusions and explanations
- use evidence (measurements, observations, patterns) to construct or support explanations and to make inferences

e) developing and using models
- develop and/or use model to explain natural phenomena
- identify limitations of models

f) obtaining, evaluating, and communicating information
- read and comprehend grade-level appropriate texts and/or other reliable media
- communicate scientific information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts

~~Force, Motion, and Energy~~

~~4.2 The student will investigate and understand characteristics and interactions of moving objects. Key concepts include~~
~~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.~~

~~Life Processes~~ Living Systems and Processes

4.~~4~~2 The student will investigate and understand~~-~~ that ~~basic~~ plant and animals have internal and external structures that distinguish them from one another and play vital roles in the ability of organisms to survive and thrive in their environment. ~~anatomy and life processes.~~ Key ideas ~~concepts~~ include

a) the survival of plants and animals depends on photosynthesis~~the structures of typical plants and the function of each structure~~;
b) plants and animals have different structures and processes for obtaining energy~~processes and structures involved with plant reproduction~~;
c) plants and animals have different structures and processes for creating offspring~~photosynthesis~~; and
d) physical and behavioral characteristics of organisms allow them to survive~~i~~ in their environment.~~adaptations allow plants to satisfy life needs and respond to the environment.~~

~~Living Systems~~

4.~~5~~3 The student will investigate and understand ~~how~~ that plants and animals, including humans, ~~in an ecosystem~~ interact with one another and with the nonliving components in the ecosystem. Key ideas ~~concepts~~ include

a) interrelationships exist in populations, communities, and ecosystems~~plant and animal adaptations~~;
b) food webs show the flow of energy within an ecosystem~~organization of populations, communities, and ecosystems and how they interrelate~~;
c) changes in an organism's niche and habitat may occur at various stages in its life cycle~~flow of energy through food webs~~;
d) human activity may affect an organism's habitat~~habitats and niches~~; and
e) classification can be used to identify organisms.~~changes in an organism's niche at various stages in its life cycle~~~~e;~~ ~~and~~
~~a) influences of human activity on ecosystems.~~

~~Interrelationships in Earth/Space Systems~~ Earth and Space Systems

4.~~6~~4 The student will investigate and understand ~~how~~ that weather conditions and phenomena occur and can be predicted. Key ideas ~~concepts~~ include

~~b)~~a) weather measurements create a record that can be used to make weather predictions~~phenomena~~; and
b) common and extreme weather events impact ecosystems.
~~weather measurements and meteorological tools; and~~

~~a) use of weather measurements and weather phenomena to make weather predictions.~~

~~Earth Patterns, Cycles, and Change~~

4.~~7~~5 The student will investigate and understand that the planets have characteristics and a specific place in ~~organization of~~ the solar system. Key ideas ~~concepts~~ include

a) ~~the~~ planets revolve on their axes and rotate around the Sun~~in the solar system~~;
b) planets have characteristics and a specific~~the~~ order ~~of the planets~~ in the solar system; and
c) the ~~relative~~ sizes of the Sun and planets can be compared to one another.

4.6~~8~~ The student will investigate and understand that there are relationships among Earth, the M~~m~~oon, and the S~~s~~un. Key relationships ~~concepts~~ 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.~~;~~ ~~and~~
~~e) historical contributions in understanding the Earth-moon-sun system.~~

4.7 The student will investigate and understand that the ocean environment has characteristics. Key characteristics include

a) geology of the ocean floor;
b) physical properties and movement of ocean water; and
c) interaction of organisms in the ocean.

Earth Resources

4.~~8~~9 The student will investigate and understand that~~important~~ Virginia has important natural resources. Key resources ~~concepts~~ include

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

Grade Five

~~The fifth-grade standards emphasize the importance of selecting appropriate instruments for measuring and recording observations. The organization, analysis, and application of data continue to be an important focus of classroom inquiry. Science skills from preceding grades, including questioning, using and validating evidence, and systematic experimentation, are reinforced at this level. Students are introduced to more detailed concepts of sound and light and the tools used for studying them. Key concepts of matter, including those about atoms, molecules, elements, and compounds, are studied, and the properties of matter are defined in greater detail. The cellular makeup of organisms and the distinguishing characteristics of groups of organisms are stressed. Students learn about the characteristics of the oceans and Earth's changing surface.~~

~~The fifth-grade standards focus on student growth in understanding the nature of science. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature, can predict potential consequences of actions, but cannot be used to answer all questions.~~

Transforming matter and energy

Grade five science takes a deeper dive into foundational concepts in physical science, and students begin to make connections between energy and matter. Students explore how energy is transformed, and learn about electricity, sound, and light. They also learn about the composition of matter, and explore how energy can change phases of matter. They apply an understanding of force, matter, and energy when they explore how the Earth's surface changes. Students continue to develop scientific skills and processes as they pose questions and predict outcomes, plan and conduct investigations, collect and analyze data, construct explanations, and communicate information about the natural world. Mathematics and computational thinking gain importance as students advance in their scientific thinking.

Scientific Skills and Processes~~Investigation, Reasoning, and Logic~~

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

~~a) items such as rocks, minerals, and organisms are identified using various classification keys;~~

~~b) estimates are made and accurate measurements of length, mass, volume, and temperature are made in metric units using proper tools;~~

~~c) estimates are made and accurate measurements of elapsed time are made using proper tools;~~

~~d) hypotheses are formed from testable questions;~~

~~e) independent and dependent variables are identified;~~
~~f) constants in an experimental situation are identified;~~
~~g) data are collected, recorded, analyzed, and communicated using proper graphical representations and metric measurements;~~
~~h) predictions are made using patterns from data collected, and simple graphical data are generated;~~
~~i) inferences are made and conclusions are drawn;~~
~~j) models are constructed to clarify explanations, demonstrate relationships, and solve needs; and~~
~~k) current applications are used to reinforce science concepts.~~

a) asking questions and defining problems
- ask testable questions based on observations and predict reasonable outcomes based on patterns
- define design problems that can be solved through the development of an object, tool, process, or system

b) planning and carrying out investigations
- collaboratively plan and conduct investigations to produce data
- identify independent and dependent variables and constants
- determine data that should be collected to answer a testable question
- make metric measurements using appropriate tools
- use tools and/or materials to design and/or build a device that solves a specific problem

c) interpreting, analyzing, and evaluating data
- represent and analyze data using tables and line graphs
- organize simple data sets to reveal patterns that suggest relationships
- 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
- develop models using an analogy, example, or abstract representation to describe a scientific principle or design solution
- identify limitations of a model

f) obtaining, evaluating, and communicating information
- read and comprehend grade-level appropriate texts and/or other reliable media
- communicate scientific and or simple technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts

Force, Motion, and Energy

5.2 The student will investigate and understand that energy can take many forms~~how sound is created and transmitted, and how it is used~~. Key ideas ~~concepts~~ include

a) ~~compression waves~~energy is the ability to do work or to cause change;
b) there are many different forms of energy~~vibration, compression, wavelength, frequency, amplitude~~;
c) energy can be transformed~~the ability of different media (solids, liquids, and gases) to transmit sound~~; and
d) energy can be conserved~~uses and applications of sound waves~~.

5.3 The student will investigate and understand that there is a relationship between force and energy of moving objects. ~~basic characteristics of visible light and how it behaves.~~ Key ideas ~~concepts~~ include

a) moving objects have kinetic energy~~transverse waves~~;
b) motion is described by an object's direction and speed~~the visible spectrum~~;
c) changes is motion are related to net force and mass~~opaque, transparent, and translucent~~;
d) the application of direct or indirect forces can cause objects to move~~reflection of light from reflective surfaces~~; ~~and~~
e) when objects collide, the contact forces transfer energy and can change objects' motion; and ~~refraction of light through water and prisms.~~
f) 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 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;
e) a current flowing through a wire creates a magnetic field; and
f) electricity has many applications.

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.

5.6 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) materials transmit light in different ways;

d) lights reflects off some surfaces; and
e) refraction of light occurs as it passes through water and prisms.

Matter

5.74 The student will investigate and understand that there are -properties and interactions of matterthat matter is anything that has mass and takes up space; and occurs as a solid, liquid, or gas. Key ideas concepts include

b)a) matter has mass and takes up spacedistinguishing properties of each phase of matter;

c)b) matter is composed of atomsthe effect of temperature on the phases of matter;

d)c) atoms -of different elements can combine to form new substances with new propertiesand elements;

e)d) substances can be mixed together without changes in their physical propertiesmolecules and compounds; and

f)e) energy has an effect on the phases of mattermixtures including solutions.

Living Systems

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;

b) classification of organisms using physical characteristics, body structures, and behavior of the organism; and

c) traits of organisms that allow them to survive in their environment.

Interrelationships in Earth and/ Space Systems

5.86 The student will investigate and understand that Earth constantly changescharacteristics of the ocean environment. Key ideas concepts include

c)a) Earth's internal energy causes movement of material within the earthgeological characteristics;

b) plate tectonics describe movement of the crust physical characteristics; and

c) the rock cycle shows continuous transitions that rocks undergo through time;ecological characteristics.

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.

Earth Resources Patterns, Cycles, and Change

5.7 The student will investigate and understand how Earth's surface is constantly changing. Key concepts include

a) identification of rock types;

b) the rock cycle and how transformations between rocks occur;

~~c) Earth history and fossil evidence;~~
~~d) the basic structure of Earth's interior;~~
~~e) changes in Earth's crust due to plate tectonics;~~
~~f) weathering, erosion, and deposition; and~~
~~g) human impact.~~

5.9 The student will investigate and understand that energy and matter are conserved. Key ideas include

a) there is a finite amount of energy and matter;
b) some forms of energy and matter are considered renewable and others are not;
c) varied sources of renewable and nonrenewable energy exist; and
d) individuals and communities have means of conserving both energy and matter.

Grade Six

~~The sixth-grade standards continue to emphasize data analysis and experimentation. Methods are studied for testing the validity of predictions and conclusions. Scientific methodology, focusing on precision in stating hypotheses and defining dependent and independent variables, is strongly reinforced. The concept of change is explored through the study of transformations of energy and matter. The standards present an integrated focus on the role of the sun's energy in Earth's systems, on water in the environment, on air and atmosphere, and on basic chemistry concepts. A more detailed understanding of the solar system and space exploration becomes a focus of instruction. Natural resource management, its relation to public policy, and cost/benefit tradeoffs in conservation policies are introduced.~~

~~The sixth-grade standards continue to focus on student growth in understanding the nature of science. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature and can predict potential consequences of actions, but cannot be used to answer all questions.~~

Our world; our responsibility

In sixth grade, students are transitioning from elementary to middle school. The science standards support that transition as students examine more abstract concepts, providing a foundation in the disciplines of science. They explore the characteristics of their world, from the Earth's placement in the solar system to the interactions of water, energy, air, and ecosystems on the Earth. As students more closely examine the use of resources, they also consider how their actions and choices affect future habitability on Earth. Students continue to develop scientific skills and processes as they pose questions and predict outcomes, plan and conduct investigations, collect and analyze data, construct explanations, and communicate information about the natural world. Mathematics and computational thinking gain importance as students advance in their scientific thinking.

~~Scientific Investigation, Reasoning, and Logic~~

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

~~a. observations are made involving fine discrimination between similar objects and organisms;~~

~~b. precise and approximate measurements are recorded;~~

~~c. scale models are used to estimate distance, volume, and quantity;~~

~~d. hypotheses are stated in ways that identify the independent and dependent variables;~~

~~e. a method is devised to test the validity of predictions and inferences;~~
~~f. one variable is manipulated over time, using many repeated trials;~~
~~g. data are collected, recorded, analyzed, and reported using metric measurements and tools;~~
~~h. data are analyzed and communicated through graphical representation;~~
~~i. models and simulations are designed and used to illustrate and explain phenomena and systems; and~~
~~j. current applications are used to reinforce science concepts.~~

a) asking questions and defining problems
- ask questions to determine relationships between independent and dependent variables
- develop hypotheses identifying independent and dependent variables
- offer simple solutions to design problems

b) planning and carrying out investigations
- independently and collaboratively plan and conduct observational and experimental investigations; identify variables, constants, and controls where appropriate, including the safe use of chemicals and equipment
- evaluate the accuracy of various methods for collecting data
- make metric measurements using appropriate tools
- use tools and/materials to design and/or build a device to solve a specific problem

c) interpreting, analyzing, and evaluating data
- organize data sets to reve~~i~~al patterns that suggest relationships
- 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 includes 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 based on how well they meet the criteria and constraints

e) developing and using models
- use scale models to represent and estimate distance
- use, develop, and revise models to predict and explain phenomena
- 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
- 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

~~Force, Motion, and Energy~~

6.2 The student will investigate and understand that the solar system is organized and the various bodies in the solar system interact. ~~basic sources of energy, their origins, transformations, and uses.~~ Key ~~concepts~~ ideas include

~~b)~~a) there are many components to the solar system~~potential and kinetic energy~~;

~~c)~~b) planets have different sizes and orbit at different distances from the Sun~~the role of the sun in the formation of most energy sources on Earth~~;

~~d)~~c) gravity contributes to ~~determines~~ orbital motion~~nonrenewable energy sources~~; and

~~e)~~d) the understanding of the solar system has developed over time.~~renewable energy sources; and~~

~~a) energy transformations.~~

6.3 The student will investigate and understand that there is a relationship between the Sun,~~the~~ 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 ~~and~~ the seasons; and

e) the relationship of Earth and the Moon is the primary cause of tides.

6.~~4~~3 The student will investigate and understand ~~-~~ that there are basic sources of energy and that energy can be transformed ~~the role of solar energy in driving most natural processes within the atmosphere, the hydrosphere, and on Earth's surface~~. Key ideas ~~concepts~~ include

a) the Sun is important in the formation of most energy sources on Earth;

~~n)~~b) Earth's energy budget relates to living systems and Earth's processes;

~~o)~~c) ~~the role of~~ radiation, conduction, and convection distribute ~~in the distribution of~~ energy; and

~~p)~~d) energy transformations are important in energy usage. ~~the motion of the atmosphere and the oceans;~~

~~a) cloud formation; and~~

~~b) the role of thermal energy in weather-related phenomena including thunderstorms and hurricanes.~~

~~**Matter**~~

6.~~5~~4 The student will investigate and understand that all matter is composed ~~made up~~ of atoms. Key ideas ~~concepts~~ include

~~e)~~a) atoms consist of particles, including electrons, protons, and neutrons;

f)b) atoms of a particular element are alike but are different from atoms of other elements;
g)c) elements may be represented by chemical symbols;
h)d) two or more atoms interact to form new substances, which are held together by electrical forces (bonds);
i)e) compounds may be represented by chemical formulas;
j)f) chemical equations can be used to model chemical changes; and
k)g) a limited number of elements comprise the largest portion of the solid Earth, living matter, the oceans, and the atmosphere.

6.65 The student will investigate and understand that water the has unique physical properties and characteristics of water and its has a roles in the natural and human-made environment. Key concepts ideas include
g)a) water asis called the universal solvent;
h)b) water has thespecific properties of water in all three phases;
c) thermal energy has a role in phase changes;
i)d) the action of water has a role in physical and chemical weathering;
j)e) the ability of large bodies of water to store thermal energy and moderate climate; and
k)f) the importance of water is important for agriculture, power generation, and public health;. and
f) the importance of protecting and maintaining water resources.

6.76 The student will investigate and understand that air has the properties of air and that Earth's atmosphere has the structure and is dynamics of Earth's atmosphere. Key concepts ideas include
a) air is as a mixture of gaseous elements and compounds;
b) the atmosphere has physical characteristicspressure, temperature, and humidity;
c) the atmospheric atmosphere changes with altitude;
d) the atmosphere movesnatural and human-caused changes to the atmosphere and the importance of protecting and maintaining air quality;
e) there is a relationship of between atmospheric measures, thermal energy, and weather conditions; and
f) weather maps give basic information about from weather maps, including fronts, systems, and basic weather measurements.

Living Systems

6.87 The student will investigate and understand the natural processes and human interactions that affect both land and water have roles in watershed systems. Key ideas concepts include
d)a) the health of ecosystems and the abiotic factors of a watershed is composed of the land that drains into a body of water;
e)b) Virginia is composed of multiple watershed systems which have specific features;the location and structure of Virginia's regional watershed systems;

~~f)~~c) the Chesapeake Bay is an estuary that has many important functions; and ~~divides, tributaries, river systems, and river and stream processes;~~

~~g)~~d) natural processes, human activities, and biotic and abiotic factors impact the health of a watershed system.~~wetlands;~~

~~a) estuaries;~~

~~b) major conservation, health, and safety issues associated with watersheds; and~~

~~c) water monitoring and analysis using field equipment including hand-held technology.~~

~~**Interrelationships in Earth/Space Systems**~~

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

~~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.~~

~~**Earth Resources**~~

6.9 The student will investigate and understand that humans impact the environment and individuals can influence public policy decisions ~~relating~~ related to energy and the environment. Key ideas ~~concepts~~ include

~~b)~~a) resources are important to protect and maintain~~management of renewable resources~~;

~~c)~~b) ~~management of~~ 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;

~~d)~~e) preventative measures can protect ~~the mitigation of~~ land-use and reduce environmental hazards ~~through preventive measures~~; and

f) there are cost/benefit tradeoffs in conservation policies.

Life Science

The Life Science standards emphasize a more complex understanding of change, cycles, patterns, and relationships in the living world. Students build on basic principles related to these concepts by exploring the cellular organization and the classification of organisms; the dynamic relationships among organisms, populations, communities, and ecosystems; and change as a result of the transmission of genetic information from generation to generation. Students build on their scientific investigation ~~Inquiry~~ skills through more independent identification of questions and planning of investigations~~at this level include organization and mathematical analysis of data, manipulation of variables in experiments, and identification of sources of experimental error~~. Students evaluate the usefulness and limits of models and support their conclusions using evidence~~Metric units (SI – International System of Units) are expected to be used as the primary unit of measurement to gather and report data at this level~~. Mathematics and computational thinking gain importance as students advance in their scientific thinking.

~~The Life Science standards continue to focus on student growth in understanding the nature of science. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature and can predict potential consequences of actions, but cannot be used to answer all questions.~~

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

~~a) data are organized into tables showing repeated trials and means;~~
~~b) a classification system is developed based on multiple attributes;~~
~~c) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, and probeware are used to gather data;~~
~~d) models and simulations are constructed and used to illustrate and explain phenomena;~~
~~e) sources of experimental error are identified;~~
~~f) dependent variables, independent variables, and constants are identified;~~
~~g) variables are controlled to test hypotheses, and trials are repeated;~~
~~h) data are organized, communicated through graphical representation, interpreted, and used to make predictions;~~
~~i) patterns are identified in data and are interpreted and evaluated; and~~
~~j) current applications are used to reinforce life science concepts.~~

a) asking questions and defining problems

- ask questions and develop hypotheses to determine relationships between independent and dependent variables
- offer simple solutions to design problems

b) planning and carrying out investigations
- independently and collaboratively plan and conduct observational and experimental investigations; identify variables, constants, and controls where appropriate, including the safe use of chemicals and equipment
- evaluate the accuracy of various methods for collecting data
- make metric measurements using appropriate tools and technologies to include the use of microscopes

c) interpreting, analyzing, and evaluating data
- identify, interpret, and evaluate patterns in data
- construct, analyze, and interpret graphical displays of data
- compare and contrast data collected by different groups and discuss similarities and differences in their findings
- consider limitations of data analysis and/or seek to improve precision and accuracy of data
- classify organisms based on multiple attributes
- 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

f) obtaining, evaluating, and communicating information
- 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 oral and written argument supported by empirical evidence and scientific reasoning

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 ~~concepts~~ ideas include

~~b)~~a) cell structure and organelles support life processes;

~~c)~~b) ~~similarities and differences between~~ plant and animal cells are both similar and different in how they support life processes;

~~d) development of cell theory; and~~

e)c) cell division is the mechanism for growth and reproduction.;
d) cellular transport (osmosis and diffusion) is important for life processes.

LS.3 The student will investigate and understand that there are levels of structural ~~that living things show patterns of cellular~~ organization in living things. Key ~~concepts~~ ideas include
~~a) cells, tissues, organs, and systems; and~~
~~b)~~a) patterns of cellular organization support ~~and their relations to~~ life processes.
b) unicellular and multicellular organisms have comparative structures; and
c) similar characteristics determine the classification of organisms.

~~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.4~~5~~ The student will investigate and understand ~~the~~ that there are basic physical and chemical processes of energy transfer ~~photosynthesis and its~~ which are ~~importance~~ important to plant and animal life. Key ~~concepts~~ ideas include
~~a) energy transfer between sunlight and chlorophyll;~~
~~b) transformation of water and carbon dioxide into sugar and oxygen; and~~
~~c)~~a) photosynthesis ~~as~~ is the foundation of virtually all food webs.;
b) photosynthesis supports life processes; and
c) organisms utilize cellular respiration.

LS.5~~6~~ The student will investigate and understand that biotic and abiotic factors ~~that organisms within an ecosystem are dependent on one another and on nonliving components of the environment~~ interact in an ecosystem. Key ideas ~~concepts~~ include
~~l)~~a) matter moves through ecosystems via the carbon, water, and nitrogen cycles;
~~m)~~b) energy flow is represented by food webs and energy pyramids; ~~interactions resulting in a flow of energy and matter throughout the system;~~and
~~n)~~c) ~~complex~~ relationships exist among producers, consumers, and decomposers. ~~within terrestrial, freshwater, and marine ecosystems; and~~
~~a) energy flow in food webs and energy pyramids.~~

~~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~~
~~b) influence of behavior on a population.~~

LS.6~~8~~ The student will investigate and understand that ~~interactions among~~ populations in a biological community interact and are interdependent. Key ~~concepts~~ ideas include

~~a) the relationships among producers, consumers, and decomposers in food webs;~~

~~b)~~a) ~~the~~ relationships exist between predators and prey and these relationships are modeled in food webs;

~~c)~~b) the availability and use of resources may lead to competition and cooperation;

~~d)~~c) symbiotic relationships support the survival of different species; and

~~e)~~d) the niche~~s~~ of each organism supports survival.

LS.7~~9~~ The student will investigate and understand ~~how~~ that adaptations support an organisms survival ~~adapt to biotic and abiotic factors~~ in an ecosystem. Key ~~concepts~~ ideas include

a) biotic and abiotic factors define land, marine, and freshwater ecosystems~~differences between ecosystems and biomes~~; and

b) physical and behavioral characteristics enable organisms to survive within a specific ecosystem.~~of land, marine, and freshwater ecosystems; and~~

~~a) adaptations that enable organisms to survive within a specific ecosystem.~~

LS.8~~10~~ The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and ~~,~~ change over time~~, and respond to daily, seasonal, and long-term changes in their environment~~. Key ideas ~~concepts~~ include

a) organisms respond to daily, seasonal, and long-term changes;

~~a) phototropism, hibernation, and dormancy;~~

b) changes in the environment may ~~factors that~~ increase or decrease population size; and

c) large-scale changes such as eutrophication, climate changes, and catastrophic disturbances affect ecosystems.

LS.9~~11~~ The student will investigate and understand ~~the~~ that relationships exist between ecosystem dynamics and human activity. Key ideas ~~concepts~~ include

~~a) food production and harvest;~~

~~b)~~a) change~~s~~ in habitat can disturb populations~~size, quality, or structure~~;

~~c)~~b) disruptions in ecosystems can change ~~in~~ species competition; and

~~d)~~c) variations in biotic and abiotic factors can change ecosystems.~~population disturbances and factors that threaten or enhance species survival; and~~

~~e) environmental issues.~~

LS.10~~2~~ The student will investigate and understand that organisms reproduce and transmit genetic information to new generations. Key ideas ~~concepts~~ include

a) ~~the structure and role of~~ the structure of DNA is related to its role;

b) ~~the function of~~ genes code for proteins and chromosomes~~;~~ transmit genetic information;

c) Punnett squares are mathematical models used to predict the probability of traits in offspring~~genotypes and phenotypes~~; and

d) traits expressed through genes may be inherited. ~~characteristics that can and cannot be inherited;~~

~~a) genetic engineering and its applications; and~~

~~b) historical contributions and significance of discoveries related to genetics.~~

LS.11~~3~~ The student will investigate and understand that populations of organisms can change over time. Key ideas ~~concepts~~ include

~~h)~~a) ~~the relationships of~~ mutation, adaptation, natural selection, and extinction change populations;

~~i)~~b) ~~evidence of evolution of different species in~~ the fossil record, genetic information, and anatomical comparisons provide evidence for evolution; and

~~j)~~c) ~~how~~ environmental factors and ~~influences, as well as~~ genetic variation, influence survivability and ~~can lead to~~ diversity of organisms.

Physical Science

~~The Physical Science standards continue to build on skills of systematic investigation with a clear focus on variables and repeated trials. Validating conclusions using evidence and data becomes increasingly important at this level. Students will plan and conduct research involving both classroom experimentation and literature reviews from written and electronic resources. Research methods and skills highlight practical problems and questions. Students will share their work using written reports and other presentations and will continue to use metric units (SI – International System of Units) as the primary unit of measurement for gathering and reporting data.~~

The Physical Science standards stress an in-depth understanding of the nature and structure of matter and the characteristics of energy. ~~The standards place considerable emphasis on the technological application of physical science principles.~~ Major areas covered by the standards include the particle nature of mature, the organization and use of the periodic table; physical and chemical changes; ~~-~~energy transfer and transformations~~nuclear reactions; temperature and heat~~; properties of longitudinal and transverse waves~~sound; light~~; electricity and magnetism; and work, force, and motion. The standards continue to build on skills of systematic investigation with a clear focus on variables and repeated trials. Validating conclusions using evidence and data becomes increasingly important at this level. Mathematics and computational thinking gain importance as students advance in their scientific thinking.

~~The Physical Science standards continue to focus on student growth in understanding the nature of science. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature and can predict potential consequences of actions, but cannot be used to answer all questions.~~

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

~~a) chemicals and equipment are used safely;~~
~~b) length, mass, volume, density, temperature, weight, and force are accurately measured;~~
~~c) conversions are made among metric units, applying appropriate prefixes;~~
~~d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data;~~
~~e) numbers are expressed in scientific notation where appropriate;~~
~~f) independent and dependent variables, constants, controls, and repeated trials are identified;~~

~~g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted;~~
~~h) data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted;~~
~~i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted;~~
~~j) valid conclusions are made after analyzing data;~~
~~k) research methods are used to investigate practical problems and questions;~~
~~l) experimental results are presented in appropriate written form;~~
~~m) models and simulations are constructed and used to illustrate and explain phenomena; and~~
~~n) current applications of physical science concepts are used.~~

a) asking questions and defining problems
- ask questions that require empirical evidence to answer
- develop hypotheses indicating relationships between independent and dependent variables
- offer simple solutions to design problems

b) planning and carrying out investigations
- independently and collaboratively plan and conduct observational and experimental investigations; identify variables, constants, and controls where appropriate, including the safe use of chemicals and equipment
- evaluate the accuracy of various methods for collecting data
- make 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 system

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 data, including, scatterplots, line plots and consider limitations of data analysis
- apply mathematical concepts and processes to scientific questions
- use data to evaluate and refine design solutions to best meet criteria

d) constructing and critiquing conclusions and explanations
- construct scientific explanations based on valid and reliable evidence obtained from sources (including the students' own investigations)
- construct argument supported by empirical evidence 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, including scale models, to illustrate and/or explain observable and unobservable phenomena

- evaluate limitations of models

f) 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.2 The student will investigate and understand ~~-~~that ~~the nature of~~ matter is compose of atoms. Key ideas ~~concepts~~ include

~~d)~~a) our understanding of atoms has developed over time~~the particle theory of matter~~;

~~e)~~b) atoms combine in various combinations~~elements, compounds, mixtures, acids, bases, and salts~~;

~~f) solids, liquids, and gases;~~

~~g)~~c) the periodic table can be used to predict chemical and physical properties of matter; and

~~h)~~d) the kinetic molecular theory is used to predict and explain matter interactions. ~~chemical properties; and~~

~~a) characteristics of types of matter based on physical and chemical properties.~~

PS.3 The student will investigate and understand~~-~~ that matter has properties and is conserved in chemical and physical processes. ~~the modern and historical models of atomic structure.~~ Key ideas ~~concepts~~ include

~~b)~~a) pure substances can be identified based on their chemical and physical properties; ~~the contributions of Dalton, Thomson, Rutherford, and Bohr in understanding the atom; and~~

b) pure substances can undergo physical and chemical changes that may result in a change of properties; ~~the modern model of atomic structure~~.

c) compounds form through ionic and covalent bonding; and

d) balanced chemical equations model the conservation of matter.

PS.4 The student will investigate and understand that ~~the organization and use of~~ the periodic table is a model used to organize elements based on their atomic structure~~of elements to obtain information~~. Key uses ~~concepts~~ include

~~b)~~a) symbols, atomic numbers, atomic mass, chemical families (groups), and periods are identified on the periodic table; and

~~c)~~b) ~~classification of~~ elements are classified as metals, metalloids, and nonmetals.~~; and~~

~~a) formation of compounds through ionic and covalent bonding.~~

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~~ that energy is conserved. Key ~~concepts~~ ideas include

~~c)~~a) energy has many different forms~~physical changes~~;
~~d)~~b) energy is transferred and transformed~~chemical changes~~; and
~~e)~~c) energy can be transformed to meet societal needs~~nuclear reactions~~.

PS.6 The student will investigate and understand that waves are important in the movement of energy. ~~forms of energy and how energy is transferred and transformed.~~ Key ~~concepts~~ ideas include

a) energy may be transferred in the form of longitudinal and transverse waves~~potential and kinetic energy; and~~
b) some waves need a medium to transfer energy;
c) waves can interact; and
~~b)~~d) energy associated with waves has many applications. ~~mechanical, chemical, electrical, thermal, radiant, and nuclear energy.~~

~~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~~

~~a) wavelength, frequency, speed, amplitude, rarefaction, and compression;~~
~~b) resonance;~~
~~c) the nature of compression waves; and~~
~~d) technological applications of sound.~~

PS.~~7~~9 The student will investigate and understand ~~the characteristics of~~ that electromagnetic radiation has characteristics~~. transverse waves~~. Key ~~concepts~~ ideas include

a) electromagnetic radiation, including visible light, has wave characteristics and behavior~~wavelength, frequency, speed, amplitude, crest, and trough~~;
b) materials can change the behavior of electromagnetic radiation~~the wave behavior of light~~;
c) regions of the electromagnetic spectrum have specific characteristic and uses. ~~images formed by lenses and mirrors;~~

~~a) the electromagnetic spectrum; and~~
~~b) technological applications of light.~~

PS.~~8~~10 The student will investigate and understand that ~~the scientific principles of~~ work, force, and motion are related. Key ~~concepts~~ ideas include

a) motion can be described using position and time~~speed, velocity, and acceleration~~;
b) motion is described by Newton's laws ~~of motion~~; and
c) machines reduce the force required to do work. ~~work, force, mechanical advantage, efficiency, and power; and~~

~~a) technological applications of work, force, and motion.~~

PS.9~~11~~ The student will investigate and understand that there are basic principles of electricity and magnetism. Key ~~concepts~~ ideas include

~~j)~~a) an imbalance of charge generates static electricity~~, current electricity, and circuits~~;

~~k)~~b) materials have different conductive properties~~relationship between a magnetic field and an electric current~~;

~~l)~~c) electric circuits transfer energy;~~electromagnets, motors, and generators and their uses; and~~

~~m) conductors, semiconductors, and insulators.~~

d) Magnetic fields model the magnetic properties of materials;

e) electric current and magnetic fields are related; and

f) many technologies use electricity and magnetism.

Earth Science

The Earth Science standards focus on the complex nature of the Earth system, including ~~connect the study of~~ Earth's composition, structure, processes, and history; its atmosphere, fresh water, and oceans; and its environment in space as a set of complex, interacting and overlapping systems. The standards emphasize historical contributions in the development of scientific thought about Earth and space. The standards stress the interpretation of maps, charts, tables, and profiles; the use of technology to collect, analyze, and report data; and the utilization of science skills in systematic investigation. Problem solving and decision-~~-~~making are an integral part of the standards, especially as they relate to the costs and benefits of utilizing Earth's resources. Mathematics and computational thinking are important as students advance in their scientific thinking. ~~Major topics of study include plate tectonics, the rock cycle, Earth history, the oceans, the atmosphere, weather and climate, and the solar system and universe.~~

~~The Earth Science standards continue to focus on student growth in understanding the nature of science. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature and can predict potential consequences of actions, but cannot be used to answer all questions.~~

ES.1 The student will demonstrate an understanding of scientific skills and processes by

~~a) plan and conduct investigations in which~~

~~b) volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevation/depth are calculated utilizing the most appropriate tools;~~

~~c) technologies, including computers, probeware, and geospatial technologies, are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions;~~

~~d) scales, diagrams, charts, graphs, tables, imagery, models, and profiles are constructed and interpreted;~~

~~e) maps and globes are read and interpreted, including location by latitude and longitude;~~

~~f) variables are manipulated with repeated trials; and~~

~~g) current applications are used to reinforce Earth science concepts.~~

a) asking questions and defining problems

- ask questions that arise from careful observation of phenomena, examination of a model or theory, or unexpected results, and/or to seek additional information

- determine which questions can be investigated within the scope of the school laboratory or field experience
- 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

b) 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 impacts
- select and use appropriate tools and technology to collect, record, analyze, and evaluate data

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 data, including scatterplots and line plots 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

d) constructing and critiquing conclusions and explanations
- make quantitative and/or qualitative claims 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, simulations, peer review
- 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 formats

ES.2 The student will demonstrate an understanding that there are scientific concepts related to the origin and evolution of the universe~~of the nature of science and scientific reasoning and logic~~. Key ~~concepts~~ ideas include

a) the big bang theory is the current scientific explanation of the origin of universe; ~~science explains and predicts the interactions and dynamics of complex Earth systems;~~
b) stars, star systems, and galaxies change over long periods of time; ~~evidence is required to evaluate hypotheses and explanations;~~
c) characteristics of the Sun, planets, and their moons, comets, meteors, asteroids, and dwarf planets are determined by materials found in each body;~~observation and logic are essential for reaching a conclusion;~~ and
d) evidence ~~is evaluated for scientific theories~~attained through space exploration has increased our understanding of the structure and nature of our Universe.

ES.3 The student will investigate and understand that Earth is unique in our Solar System. ~~the characteristics of Earth and the solar system.~~ Key ~~concepts~~ ideas include

~~k)~~a) ~~position of~~ Earth ~~-~~ supports life because of its relative proximity to the sun and other factors~~in the solar system~~; and
~~l)~~b) the dynamics of the S~~s~~un-Earth-~~moon~~ Moon system ~~relationships~~ cause~~;~~ ~~(~~seasons, tides, and eclipses~~).~~;

~~a) characteristics of the sun, planets and their moons, comets, meteors, and asteroids; and~~
~~b) the history and contributions of space exploration~~

~~.~~

ES.4 The student will investigate and understand ~~-~~that there are major rock-forming and ore mineral~~s~~~~how to identify major rock-forming and ore minerals based on physical and chemical properties~~. Key ~~concepts~~ ideas include

a) analysis of physical and chemical properties supports mineral identification; ~~hardness, color and streak, luster, cleavage, fracture, and unique properties; and~~
b) characteristics of minerals determine the uses of minerals; and~~.~~
c) rock-forming minerals originate and are formed in specific ways.

ES.5 The student will investigate and understand~~-~~ that igneous, metamorphic, and sedimentary rocks can transform. ~~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~~ ideas include

a) Earth materials are finite and transformed over time~~igneous rocks~~;
b) the rock cycle models the transformation of rocks~~sedimentary rocks~~; ~~and~~
c) layers of Earth have rocks with specific chemical and physical properties; and ~~metamorphic rocks.~~
d) plate tectonic and surface processes transform Earth materials.

ES.6 The student will investigate and understand~~~~ that resource use is complex. ~~the differences between renewable and nonrenewable resources.~~ Key ideas ~~concepts~~ include

~~e)~~a) ~~fossil fuels, minerals, rocks, water, and vegetation~~global resource use has environmental liabilities and benefits;
~~f)~~b) ~~advantages and disadvantages of various energy sources~~availability, renewal rates, and economic impact are considerations when using resources;
~~g)~~c) ~~resources found in Virginia~~use of Virginia resources has an impact on the environment and the economy; and
~~h)~~d) ~~environmental costs and benefits~~the selection of various energy sources has environmental and economic impacts.

ES.7 The student will investigate and understand ~~geologic processes including~~ that plate tectonic~~s~~ theory explains Earth's internal and external geologic processes. Key ideas ~~concepts~~ include

a) convection currents in Earth's interior lead to the movement of plates, creation of the magnetic field, and the distribution of materials in Earth's layers~~;geologic processes and their resulting features~~; ~~and~~
b) features and processes occur within plates and at plate boundaries;~~tectonic processes.~~
c) interaction between tectonic plates causes the development of mountain ranges and ocean basins; and
d) evidence of geologic processes are found in Virginia's geologic landscape.

ES.8 The student will investigate and understand ~~how~~ that freshwater resources influence and are influenced by geologic processes and ~~the~~ activities of humans. Key ~~concepts~~ ideas include

~~b)~~a) water impacts geologic processes including ~~processes of~~ soil development and karst topography;
~~c) development of karst topography;~~
~~d)~~b) ~~relationships between~~the nature of materials in the subsurface affect ~~groundwater zones, including saturated and unsaturated zones, and~~ the water table and future availability of fresh water;
~~e) identification of sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle;~~

~~f)~~c) weather and human usage impact ~~dependence on~~ freshwater resources, including water locations, quality, and supply; ~~and the effects of human usage on water quality;~~ and

~~g)~~d) stream processes and dynamics impact ~~identification of~~ 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~~ ideas include

~~c)~~a) traces and remains of ancient, often extinct, life are preserved by various means in ~~many~~ sedimentary rocks;

~~d)~~b) superposition, cross-cutting relationships, index fossils, and radioactive decay are methods of dating ~~bodies of~~ rocks and Earth events and processes;

~~e)~~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, dynamic systems ~~interactive physical, chemical, and biological systems~~ and are subject to long- and short-term variations. Key ~~concepts~~ ideas include

a) ~~physical and~~ chemical, biological, and physical changes ~~related to tides, waves, currents, sea level and ice cap variations, upwelling, and salinity variations~~impact the oceans;

b) ~~importance of~~ environmental and geologic ~~implications~~occurrences affect ocean dynamics;

c) ~~systems interactions~~unevenly distributed heat in the oceans drives much of Earth's weather;

d) features of the sea floor ~~as~~ reflect ~~ions of~~ tectonic and other geological processes; and

e) human actions, including economic and public policy issues, ~~concerning~~ impact ~~the~~ oceans and the coastal zone including the Chesapeake Bay.

ES.11 The student will investigate and understand that ~~the origin and evolution of~~ the atmosphere is a complex, dynamic system and is subject to long-and short-term variations ~~and the interrelationship of geologic processes, biologic processes, and human activities on its composition and dynamics~~. Key ~~concepts~~ ideas include

~~b)~~a) ~~scientific evidence for atmospheric~~ the composition of the atmosphere is critical to most forms of life ~~changes over geologic time~~;

~~c)~~b) ~~current theories related to the effects of early life on the chemical makeup of the~~ biologic and geologic interactions over long and short time spans change ~~atmosphere~~ atmospheric composition;

~~d)~~c) natural events and human actions may stress atmospheric regulation mechanisms ~~including the effects of density differences and energy transfer~~; and

~~e)~~d) human actions, including economic and policy decisions, impact the atmosphere. ~~potential changes to the atmosphere and climate due to human, biologic, and geologic activity.~~

ES.12 The student will investigate and understand that ~~energy transfer between the sun and~~ Earth's weather and climate are~~is~~ the result of the interaction of the Sun's energy with the atmosphere, oceans, and the land. ~~and its atmosphere drives weather and climate on Earth .~~ Key ~~concepts~~ ideas include

a) weather involves the reflection, absorption, storage, and redistribution of energy over short to medium time spans~~observation and collection of weather data~~;

b) weather patterns can be ~~prediction~~ predicted based on changes in current conditions~~of weather patterns~~;~~—~~

c) extreme imbalances in energy distribution in the oceans, atmosphere, and the land may lead to severe weather ~~occurrences, such as tornadoes, hurricanes, and major storms~~conditions; ~~and~~

d) models based on current conditions are used to predict weather phenomena ~~and the factors that affect climate including radiation, conduction, and convection~~; and~~.~~

e) changes in the atmosphere and the oceans due to human activity affect global climate.

~~ES.13 The student will investigate and understand scientific concepts related to the origin and evolution of the universe. Key concepts include~~

- ~~cosmology including the Big Bang theory; and~~
- ~~the origin and evolution of stars, star systems, and galaxies.~~

Biology

The Biology standards are designed to provide students with a detailed understanding of living systems. Students investigate biochemical life processes, cellular organization, mechanisms of inheritance, dynamic relationships among organisms, and the change in organisms through time. ~~Emphasis continues to be placed on the skills~~ Skills necessary to examine ~~alternative~~ scientific explanations, ~~actively~~ conduct ~~controlled~~ experiments, analyze and communicate information, and gather and use information in scientific literature continues to be important. ~~The history of biological thought and the evidence that supports it are explored, providing the foundation for investigating~~ ~~Students investigate biochemical life processes, cellular organization, mechanisms of inheritance, dynamic relationships among organisms, and the change in organisms through time.~~ The importance of scientific research that validates or challenges ideas is emphasized at this level. Tools and technology, including calculators, computers, probeware, and microscopes are used when feasible. Students will use chemicals and equipment safely. Mathematics and computational thinking are important as students advance in their scientific thinking. ~~All students are expected to achieve the content of the biology standards.~~

~~The Biology standards continue to focus on student growth in understanding the nature of science. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature and can predict potential consequences of actions, but cannot be used to answer all questions.~~

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

~~a) observations of living organisms are recorded in the lab and in the field;~~
~~b) hypotheses are formulated based on direct observations and information from scientific literature;~~
~~c) variables are defined and investigations are designed to test hypotheses;~~
~~d) graphing and arithmetic calculations are used as tools in data analysis;~~
~~e) conclusions are formed based on recorded quantitative and qualitative data;~~
~~f) sources of error inherent in experimental design are identified and discussed;~~
~~g) validity of data is determined;~~
~~h) chemicals and equipment are used in a safe manner;~~
~~i) appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data, communicating results, modeling concepts, and simulating experimental conditions;~~
~~j) research utilizes scientific literature;~~

~~k) differentiation is made between a scientific hypothesis, theory, and law;~~
~~l) alternative scientific explanations and models are recognized and analyzed; and~~
~~m) current applications of biological concepts are used.~~

a) asking questions and defining problems
- ask questions that arise from careful observation of phenomena and/or organisms or from examining models and theories, or unexpected results, and/or to seek additional information
- determine which questions can be investigated within the scope of the school laboratory or field to determine relationships between independent and dependent variables
- make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated

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 and ethical manner including considerations of environmental, social, and personal impacts
- determine appropriate sample size and techniques
- select and use appropriate tools and technology to collect, record, analyze, and evaluate data

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 data, including scatterplots and line plots and consider limitations of data analysis
- apply mathematical concepts and processes to scientific questions
- use data in building and revising models, supporting 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, 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
- 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~~ that chemical and biochemical ~~principles~~ processes are essential for life. Key ~~concepts~~ ideas include

a) water chemistry ~~and its~~has an impact on life processes;
b) ~~the structure and function of~~ macromolecules have a role in maintaining life processes;
c) ~~the nature of~~ enzymes have a role in biochemical processes; ~~and~~
d) protein synthesis is the process of forming proteins; and
~~d)~~e) the processes of photosynthesis and respiration include the capture, storage, transformation, and flow of energy ~~through the processes of photosynthesis and respiration~~.

BIO.3 The student will investigate and understand ~~relationships between~~ that cells have structure and function. Key ~~concepts~~ ideas include

a) ~~evidence supporting~~ the cell theory is supported by evidence;
b) ~~characteristics of prokaryotic and eukaryotic cells~~homeostasis is maintained through the role of structures in unicellular and multicellular organisms; ~~—~~
c) ~~similarities between the activities of the organelles in a single cell and a whole organism~~cell structures and processes are involved in cell growth and division;
d) the structure and function of the cell membrane model support cell transport; and
e) ~~the impact of surface area to volume ratio on cell division, material transport, and other life processes~~specialization leads to the development of different types of cells.

BIO.4 The student will investigate and understand that bacteria and viruses have an impact on living systems.~~life functions of Archaea, Bacteria and Eukarya~~. Key ~~concepts~~ ideas include

a) ~~comparison of~~ their metabolic activities can be compared;

b) ~~maintenance of homeostasis~~the modes of reproduction/replication can be compared;
c) ~~how~~ the structures and functions can be compared ~~vary among and within the Eukarya kingdoms of protists, fungi, plants, and animals, including humans~~;
d) ~~human health issues, human anatomy, and body systems~~bacteria and viruses have a role in other organisms and the environment; and ~~;~~
~~e) how viruses compare with organisms; and~~
~~f)~~e) ~~evidence supporting~~ the germ theory of infectious disease is supported by evidence.

BIO.5 The student will investigate and understand that there are common mechanisms ~~of~~ for inheritance ~~and protein synthesis~~. Key ~~concepts~~ ideas include
~~b)~~a) ~~cell growth and division~~DNA has structure and function;
~~c)~~b) ~~gamete formation~~genes and chromosomes have structure and function;
~~d) cell specialization;~~
~~e)~~c) ~~prediction of inheritance of traits based on the~~ Mendelian laws of heredity predict inheritance traits;
~~f)~~d) ~~historical development of~~ the structural model of DNA has developed over time;
~~g)~~e) meiosis has a role in genetic variation;
~~h)~~f) nucleic acids have specific ~~the~~ structure, function, and replication ~~of nucleic acids~~;
~~i) events involved in the construction of proteins;~~
~~j)~~g) ~~use,~~ there are limitations to the use~~, and misuse~~ of genetic information; and
~~k)~~h) ~~exploration of the impact of~~ DNA technologies have biological and ethical implications.

BIO.6 The student will investigate and understand that ~~bases for~~ modern classification systems can be used as organizational tools for scientists in the study of organisms. Key ~~concepts~~ ideas include
a) organisms have structural and biochemical similarities and differences~~among organisms~~;
b) fossil record interpretation can be used to classify organisms;
c) ~~comparison of~~ developmental stages in different organisms can be used to classify organisms;
d) Archaea, Bacteria, and Eukarya are categories based on characteristics of organisms;
~~d)~~e) ~~examination of biochemical similarities and differences among organisms~~the functions and processes of protists, fungi, plants, and animals allow for comparisons and differentiation within the Eukarya kingdoms; and
~~e)~~f) systems of classification ~~that~~ are adaptable to new scientific discoveries.

BIO.7 The student will investigate and understand ~~how~~ that populations change through time. Key ~~concepts~~ ideas include
~~b)~~a) evidence is found in fossil records and through DNA analysis;

~~c)~~b) ~~how~~ genetic variation, reproductive strategies, and environmental pressures impact the survival of populations;

~~d)~~c) ~~how~~ natural selection is a mechanism that leads to adaptations;

~~e)~~d) ~~emergence of~~ new species emerge; and

~~f)~~e) biological evolution has scientific evidence and explanations. ~~for biological evolution.~~

BIO.8 The student will investigate and understand that there are dynamic equilibria within populations, communities, and ecosystems. Key ~~concepts~~ ideas include

a) interactions within and among populations ~~including~~ include carrying capacities, limiting factors, and growth curves;

b) nutrients ~~cycling~~ cycle with energy flow through ecosystems;

c) ecosystems have succession patterns ~~in ecosystems~~; and

d) ~~the effects of~~ natural events and human activities impact ~~on~~local and global ecosystems and may affect the flora and fauna of Virginia.~~; and~~

~~• analysis of the flora, fauna, and microorganisms of Virginia ecosystems.~~

Chemistry

The Chemistry standards are designed to provide students with a detailed understanding of the interaction of matter and energy. This interaction is investigated using experimentation, mathematical reasoning ~~through the use of laboratory techniques, manipulation of chemical quantities,~~ and problem-solving ~~applications~~. ~~Scientific methodology is employed in experimental and analytical investigations, and~~ concepts Areas of study include atomic theory, chemical bonding, chemical reactions, molar relationships, kinetic molecular theory, and thermodynamics. Concepts are illustrated with current practical applications that should include examples from environmental, nuclear, organic, and biochemistry content areas. Technology, including graphing calculators, computers, and probeware are used when feasible. Students will use chemicals and equipment safely. Mathematics and computational thinking are essential as students advance in their scientific thinking.

~~Technology, including graphing calculators, computers, and probeware, are employed where feasible. Students will understand and use safety precautions with chemicals and equipment. The standards emphasize qualitative and quantitative study of substances and the changes that occur in them. In meeting the chemistry standards, students will be encouraged to share their ideas, use the language of chemistry, discuss problem-solving techniques, and communicate effectively.~~

~~The Chemistry standards continue to focus on student growth in understanding the nature of science. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature and can predict potential consequences of actions, but cannot be used to answer all questions.~~

CH.1 The student will ~~investigate and understand that~~demonstrate an understanding of scientific skills and processes by ~~experiments in which variables are measured, analyzed, and evaluated produce observations and verifiable data. Key concepts include~~

~~a) designated laboratory techniques;~~
~~b) safe use of chemicals and equipment;~~
~~c) proper response to emergency situations;~~
~~d) manipulation of multiple variables, using repeated trials;~~
~~e) accurate recording, organization, and analysis of data through repeated trials;~~
~~f) mathematical and procedural error analysis;~~
~~g) mathematical manipulations including SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, and dimensional analysis;~~

~~h) use of appropriate technology including computers, graphing calculators, and probeware, for gathering data, communicating results, and using simulations to model concepts;~~
~~i) construction and defense of a scientific viewpoint; and~~
~~j) the use of current applications to reinforce chemistry concepts~~
~~k)~~
a) asking questions and defining problems
- ask questions that arise from careful observation of phenomena, examination of a model or theory, or unexpected results, and/or to seek additional information
- determine which questions can be investigated within the scope of the school laboratory
- make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated
- 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

g) 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.

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 explanation for phenomena, or testing solutions to problems
- solve problems using mathematical manipulations including SI units, scientific notation, derived units, significant digits, and dimensional analysis
- 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 predictions;
- 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 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

CH.2 The student will investigate and understand that ~~the placement of~~ elements have properties based on ~~the periodic table is a function of~~ their atomic structure. The periodic table is an organizational tool for elements based on these properties. Key information about atomic structure from the periodic table includes ~~used for the investigations of~~

a) average atomic mass, isotopes, mass number, and atomic number;

b) ~~isotopes, half-lives, and radioactive decay~~nuclear decay;

~~c) mass and charge characteristics of subatomic particles;~~

~~d) families or groups;~~

~~e) periods;~~

~~f)~~c) trends within groups and periods including atomic radii, electronegativity, shielding effect, and ionization energy;

~~g)~~d) electron configurations, valence electrons, excited electrons, and ~~oxidation numbers~~ions; and

~~h) chemical and physical properties; and~~

~~i)~~e) historical and quantum models.

CH.3 The student will investigate and understand ~~how~~ that atoms are conserved in chemical reactions. Knowledge of chemical properties of the elements can be used to describe and predict chemical interactions~~conservation of energy and matter is expressed in chemical formulas and balanced equations~~. Key ~~concepts~~ ideas include

a) ~~nomenclature~~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~~balancing chemical equations~~;

c) balanced chemical equations model rearrangement of atoms in chemical reactions~~writing chemical formulas~~;
d) atoms bond based on electron interactions~~bonding types~~;
e) molecular geometry is predictive of physical and chemical properties; and
~~e)~~f) reaction types can be predicted and classified.~~; and~~

CH.4 The student will investigate and understand that ~~chemical quantities are based on~~ molar relationships compare and predict chemical quantities. Key ~~concepts~~ ideas include
~~e)~~a) Avogadro's principle is the basis for molar relationships~~and molar volume~~; and
~~f)~~b) s~~S~~toichiometry mathematically describes quantities in chemical composition and in chemical reactions~~ic relationships.;~~
~~a) solution concentrations; and~~
~~b) acid/base theory; strong electrolytes, weak electrolytes, and nonelectrolytes; dissociation and ionization; pH and pOH; and the titration process.~~

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 change solution concentration;
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.6~~5~~ The student will investigate and understand that the phases of matter are explained by the kinetic molecular theory ~~and forces of attraction between particles.~~ Key ~~concepts~~ ideas include
~~e)~~a) pressure~~,~~ and temperature~~, and volume~~ define the phase of a substance;
~~f)~~b) ~~partial pressure and~~ properties of ideal gases are described by gas laws; and
~~g)~~c) ~~vapor pressure~~ intermolecular forces affect physical properties.~~;~~
- ~~phase changes;~~
- ~~molar heats of fusion and vaporization;~~
- ~~specific heat capacity; and~~
- ~~colligative properties.~~

~~CH.6 The student will investigate and understand how basic chemical properties relate to organic chemistry and biochemistry. Key concepts include~~
- ~~unique properties of carbon that allow multi-carbon compounds; and~~
- ~~uses in pharmaceuticals and genetics, petrochemicals, plastics, and food.~~

CH.7 The student will investigate and understand that thermodynamics explains the relationship between matter and energy. Key ideas include
a) heat energy affects both 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;
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.

Physics

The Physics standards emphasize a more complex understanding of experimentation, the analysis of data, and the use of reasoning and logic to evaluate evidence. The use of mathematics, including algebra and trigonometry~~,~~ is important, but conceptual understanding of physical systems remains a primary concern. Students build on basic physical science principles by exploring in-depth the nature and characteristics of energy and its dynamic interaction with matter. Key areas covered by the standards include force and motion, energy transformations, wave phenomena and the electromagnetic spectrum, electricity, fields, and non-Newtonian physics. Technology, including graphing calculators, computers, and probeware are used when feasible. Students will use equipment safely. Mathematics and computational thinking are essential as students advance in their scientific thinking. ~~The standards stress the practical application of physics in other areas of science, technology, engineering, and mathematics. The effects of physics on our world are investigated through the study of critical, contemporary global topics.~~

~~The Physics standards continue to focus on student growth in understanding the nature of science. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature and can predict potential consequences of actions, but cannot be used to answer all questions.~~

PH.1 The student ~~will plan and conduct investigations using experimental design and product design processes~~demonstrate an understanding of scientific skills and process by. ~~Key concepts include~~

~~a) the components of a system are defined;~~
~~b) instruments are selected and used to extend observations and measurements;~~
~~c) information is recorded and presented in an organized format;~~
~~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 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.~~

a) asking questions and defining problems
- ask questions that arise from careful observation of phenomena, examination of a model or theory, or unexpected results, and/or to seek additional information

- determine which questions can be investigated within the scope of the school laboratory
- make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated
- 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 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 impact of new data on a working explanation and/or model of a proposed process or system
- analyze data to optimize a design

d) constructing and critiquing conclusions and explanations
- make quantitative and/or qualitative claims based on data
- 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 description of a physical problem is translated into a mathematical statement in order to find a solution;~~
- ~~relationships between physical quantities are determined using the shape of a curve passing through experimentally obtained data;~~
- ~~the slope of a linear relationship is calculated and includes appropriate units;~~
- ~~interpolated, extrapolated, and analyzed trends are used to make predictions; and~~
- ~~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~~

- ~~analysis of scientific sources to develop and refine research hypotheses;~~
- ~~analysis of how science explains and predicts relationships;~~
- ~~evaluation of evidence for scientific theories;~~
- ~~examination of how new discoveries result in modification of existing theories or establishment of new paradigms; and~~
- ~~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~~

- ~~examples from the real world; and~~
- ~~exploration of the roles and contributions of science and technology.~~

PH.2~~5~~ The student will investigate and understand, through mathematical and experimental processes,~~-~~ ~~the~~ that there is a ~~inter~~relationship~~s~~ ~~among mass, distance, force, and time through mathematical and experimental processes~~between position and time. Key ~~concepts~~ topics include

a) displacement, velocity, and uniform acceleration;

~~c)~~b) linear motion;

~~d)~~c) uniform circular motion; and

~~e)~~d) projectile motion~~s~~;.

- ~~Newton's laws of motion;~~
- ~~gravitation;~~
- ~~planetary motion; and~~

- ~~work, power, and energy.~~

PH.~~6~~3 The student will investigate and understand, through mathematical and experimental processes, that there is a relationship~~s~~ among force, mass, and acceleration. ~~that quantities including mass, energy, momentum, and charge are conserved.~~ Key ~~concepts~~ laws include

~~b)~~a) ~~kinetic and potential energy~~Newton's Law of Motion; and

~~c)~~b) ~~elastic and inelastic collisions; and~~Newton's Law of Universal Gravitation.

~~a) mass/energy equivalence.~~

PH.~~7~~4 The student will investigate and understand, through mathematical and experimental processes, that ~~energy can be transferred and transformed to provide usable work~~conservation laws govern all interactions. Key ~~concepts~~ ideas include

a) ~~transfer and storage of energy among systems including mechanical, thermal, gravitational, electromagnetic, chemical, and nuclear systems; and~~ momentum of a system may be conserved;

b) ~~efficiency of systems.~~ an external force can change the momentum of a system;

c) mechanical energy of a system may be conserved; and

d) energy may be transformed by work.

PH.~~8~~5 The student will investigate and understand, through mathematical and experimental processes, ~~that~~ waves transmit energy and move in predictable patterns ~~phenomena~~. Key ~~concepts~~ ideas include

a) waves have specific characteristics;

b) ~~fundamental wave processes~~wave interactions are part of everyday experiences; and

c) light and sound ~~in terms of wave models~~can be modeled as waves.

PH.~~9~~6 The student will investigate and understand, through mathematical and experimental processes, ~~that different frequencies and wavelengths in the electromagnetic spectrum are phenomena ranging from radio waves through visible light to gamma radiation.~~that optical systems form a variety of images. ~~:~~ Key ~~concepts~~ ideas include

a) ~~the properties, behaviors, and relative size of radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays~~the laws of reflection and refraction describe light behavior; and~~;~~

b) ~~wave/particle dual nature of light; and~~ray diagrams model light as it travels through different media.

~~a) current applications based on the respective wavelengths.~~

PH.~~10~~7 The student will investigate and understand, through mathematical and experimental processes, that ~~how to use the~~ fields ~~concept to describe the effects~~

~~of gravitational, electric, and magnetic forces.~~provide a unifying description of force at a distance. Key ideas ~~concepts~~ include

~~c)~~a) gravitational, electric, and magnetic forces can be described using the field concept; ~~inverse square laws (Newton's law of universal gravitation and Coulomb's law);~~ and

~~d)~~b) ~~technological applications~~field strength diminishes with distance from the source.

PH.~~11~~8 The student will investigate and understand, through mathematical and experimental processes, ~~how to diagram, construct, and analyze basic~~ that electrical circuits are a system used to transfer energy ~~and explain the function of various circuit components~~. Key ~~concepts~~ ideas include

a) ~~Ohm's law~~ circuit components have different functions within the system;

b) ~~series, parallel, and combined circuits~~Ohm's law relates voltage, current, and resistance;

c) ~~electrical power~~different types of circuits have different characteristics and are used for different purposes; ~~and~~

d) ~~alternating direct currents.~~electrical power is related to the elements in a circuit; and

e) electrical circuits have everyday applications.

PH.~~12~~9 The student will investigate and understand that extremely large and extremely small quantities are not necessarily described by the same laws as those studied in Newtonian physics. Key ~~concepts~~ topics may include

a) wave/particle duality;

~~b) wave properties of matter;~~

~~c) matter/energy equivalence;~~

~~d)~~b) quantum mechanics and uncertainty;

~~e)~~c) relativity;

~~f)~~d)nuclear physics;

~~g)~~e) solid state physics;

~~h)~~f)nanotechnology;

~~i)~~g)superconductivity; ~~and~~

~~j)~~h)the standard model; and~~radioactivity.~~

i) dark matter and dark energy.