Board of Education Agenda Item

Item: J. **Date:** October 22, 2009

Topic: First Review of Proposed Revised *Science Standards of Learning*

Presenter: Ms. Paula Klonowski, Science Coordinator

Telephone Number: (804) 371-0249 **E-Mail Address:** Paula.Klonowski@doe.virginia.gov

Origin:

____ Topic presented for information only (no board action required)

__X__ Board review required by
- __X__ State or federal law or regulation
- ____ Board of Education regulation
- ____ Other: _____

____ Action requested at this meeting __X__ Action requested at future meeting: After public comment

Previous Review/Action:

____ No previous board review/action

__X__ Previous review/action
Date January 15, 2009
Action Board of Education approved the timeline to proceed with the review process.

Background Information:
The Standards of Learning for science were developed in 1995 and revised in 2003. The *Standards of Quality* require the Board of Education to review the Standards of Learning on a regular schedule. The *Science Standards of Learning* are scheduled for review in 2010. As a result, on January 15, 2009, the Board approved a plan to review these standards beginning in 2009. In accordance with the plan, the Department of Education took the following steps to produce a draft of the proposed revised *Science Standards of Learning* for the Board's first review:

- Received online comments from stakeholders, including teachers, parents, and administrators that are summarized in Attachment A;
- Met with a teacher review committee that consisted of recommended individuals solicited from school divisions on July 16 and 17, 2009, to review the public comment and consider recommendations and documents from the: 1) National Assessment of Educational Progress (NAEP) Frameworks; 2) the National Science Education Standards, Benchmarks for Science Literacy; and 3) a report on the 21st century content standards in physics, chemistry and engineering in Virginia's K-12 curriculum prepared by retired staff from the National Aeronautics and Space Administration (NASA) Langley Research Center and presented to Virginia's P-16 Education Council in June 2008 and to the Board of Education as part of public comment in April, May, June, and July 2009.

- Solicited a review committee comprised of faculty from science and science education departments at postsecondary institutions and representatives from state agencies and met with them on August 6, 2009, to review and discuss their comments;
- Solicited a business and industry review committee and met with them on August 17, 2009, to review and discuss their comments; and
- Developed a draft of the proposed revised *Science Standards of Learning*.

Summary of Major Elements:
The attached draft of the proposed revised *Science Standards of Learning* (Attachment B) consists of the following elements:

Introduction
The *Science Standards of Learning* for Virginia's Public Schools identify academic content for essential components of the science curriculum at different grade levels. 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 in each strand progress in complexity as they are studied at various grade levels in grades K-6, and the strands are represented indirectly throughout the high school courses.

Goals
The purposes of scientific investigation and discovery are to satisfy humankind's quest for knowledge and understanding, to preserve and enhance the quality of the human experience, and to develop an understanding of the interrelationship of science with technology, engineering and mathematics.

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.

Instructional Technology
The use of current and emerging technologies is essential to the K-12 science instructional program.

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 the range of rigorous science skills and knowledge 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, rigorous, and inclusive content standard.

Application
Science provides the key to understanding the world in which we live. Making connections among science, technology, engineering and mathematics allows us to design and create new devices or materials that increase our efficacy in the world and our enjoyment of it. Various strategies can be used to facilitate applications of science, technology, engineering and mathematics.

Standards

The *Science Standards of Learning* for Virginia public schools describe the Commonwealth's expectations for student learning and achievement in grades K-12. The *Science Standards of Learning* are not intended to encompass the entire science curriculum for a given grade level or course or to prescribe how the content should be taught. Teachers are encouraged to go beyond the standards and to select instructional strategies and assessment methods appropriate for their students.

Summary of the Proposed Revised *Science Standards of Learning*

The major elements of the attached proposed revised *Science Standards of Learning* include:

- Edits to enhance clarity, specificity, rigor, alignment of skills and content, and a reflection of the current academic research and practice;
- The application of science concepts through technology, engineering and mathematics;
- Addition of standards in Kindergarten, Grade Four and Chemistry; and
- Deletion of standards in Life Science, Chemistry and Physics.

Superintendent's Recommendation:

The Superintendent of Public Instruction recommends that the Board of Education accept for first review the proposed revised *Science Standards of Learning*.

Impact on Resources:

This responsibility can be absorbed by the agency's existing resources at this time. If the agency is required to absorb additional responsibilities related to this activity, other services may be impacted.

Timetable for Further Review/Action:

The *Science Standards of Learning* review work plan calls for public comment, public hearings, final review, and adoption of the *Science Standards of Learning* by the Board of Education by winter 2010.

Summary of Online Comments and Review Committees' Comments on Virginia's 2003 *Science Standards of Learning*

A total of 430 comments were received online from individuals and groups for the *Science Standards of Learning* in Kindergarten through Physics during the 30-day public comment period from January 23, 2009, through February 23, 2009.

The number of comments submitted by grade level or course included:

Course	Number of Comments
Kindergarten	27
Grade 1	23
Grade 2	33
Grade 3	41
Grade 4	59
Grade 5	64
Grade 6	18
Life Science	32
Physical Science	23
Earth Science	30
Biology	29
Chemistry	19
Physics	11

There were also 21 general comments made about the K-12 *Science Standards of Learning*.

Groups submitting online comments included:

- Henrico County Public Schools elementary science teachers
- Mathews County Public Schools vertical science team
- Newport News City Public Schools elementary science lead teachers
- Powhatan County Public Schools biology teachers
- Roanoke City Public Schools biology teachers
- Department of Environmental Quality Office of Environmental Education
- James Madison University Center for STEM Education and Outreach
- Science Museum of Virginia
- Virginia Association of Science Teachers (VAST) chemistry committee
- Virginia Science Education Leadership Association (VSELA)

Three review committees met during the summer to review public comment, science reports, and pertinent national documents and to review the *2003 Science Standards of Learning* in order to make recommendations for edits to the *Science Standards of Learning*. These committees were comprised of individuals from school divisions, higher education, state agencies and business and industry. The following is a summary of input from the public online comments and the review committees regarding changes to the *Science Standards of Learning*:

- Clarify what is meant by the nature of science;
- Reorder and add to the Scientific Investigation, Reasoning, and Logic bullets in grades K-5 to provide teachers and students with a logical, coherent and comprehensive set of process skills that are foundational to understanding the nature of science and to conducting investigations;
- Include relevance to everyday life, using experiments and projects that relate science to real-life applications in science instruction, along with critical thinking skills, problem formation techniques, solution development, and abstraction and synthesis of information;
- Include project-based learning, simulation and modeling, and cross-curricular applications in science instruction;
- Apply the scientific process skills to scientific investigations, field investigations, and engineering design projects;
- Introduce the solar system before sixth grade;
- Clarify standards in K-5 dealing with plants and animals to ensure accuracy of information;
- Use consistent terminology and content in vertical alignment of the standards;
- Update standards to include references to additional energy sources;
- Include more emphasis on climate and less on weather in Earth Science, and less focus on geology;
- Move examples and details to the Curriculum Framework;
- Add organic chemistry to the Chemistry standards;
- Reduce the content in the Physics standards; and
- Incorporate nanotechnology into grades 6 through 12.

Proposed Revised Science Standards of Learning

for Virginia Public Schools

First Review

October 22, 2009

Preface

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, and business and industry leaders. The standards set clear, concise, and measurable academic expectations for young people. Parents are encouraged to work with their children to help them achieve these academic standards.

A major goal of Virginia's educational agenda is to create an excellent statewide system of public education that meets the needs of all young people in Virginia. These Standards of Learning chart the course for achieving that objective.

Introduction

The *Science Standards of Learning* for Virginia~~'s~~ Public Schools identify academic content for essential components of the science curriculum at different grade levels. 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, ~~specific~~ content strands, or topics are included. The Standards of Learning in each strand progress in complexity as they are studied at various grade levels in grades K-6, and are represented indirectly throughout the high school courses. These strands are

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

~~The Standards of Learning in each strand progress in complexity at each grade level K-6 and are represented indirectly throughout the high school courses.~~

~~The Standards of Learning are not intended to encompass the entire science curriculum for a given grade level or course or to prescribe how the content should be taught. Teachers are encouraged to go beyond the standards and to select instructional strategies and assessment methods appropriate for their students.~~ [Moved to preface]

~~Four~~ Five key components of the science standards that are critical to implementation and necessary for student success in achieving science literacy are described below. 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 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:

1. Develop and use an experimental design in scientific inquiry.
2. Use the language of science to communicate understanding.
3. Investigate phenomena, using technology.
4. Apply scientific concepts, skills, and processes to everyday experiences.
5. Experience the richness and excitement of scientific discovery of the natural world through the collaborative quest for knowledge and understanding.

6. Make informed decisions regarding contemporary issues, taking into account the following:
    - public policy and legislation;
    - economic costs/benefits;
    - validation from scientific data and the use of scientific reasoning and logic;
    - respect for living things;
    - personal responsibility; and
    - history of scientific discovery.
7. 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.
8. Develop an understanding of the interrelationship of science with technology, engineering and mathematics.

~~8.~~ 9.Explore science-related careers and interests.

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 (MSDS). 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 the following sources may be referenced:

- OSHA (Occupational Safety and Health Administration);
- ISEF (International Science and Engineering Fair) rules; and
- public health departments' and school divisions' protocols.

Instructional Technology

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, ~~interactive optical laser discs,~~ video-microscopes, graphing calculators, ~~CD-ROMs,~~

probeware, ~~global positioning systems (GPS)~~geospatial technologies, online ~~tele~~communication, software and appropriate hardware, as well as other emerging technologies.

- 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.

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 the range of rigorous science skills and knowledge 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:

- observing;
- classifying and sequencing;
- communicating;
- measuring;
- predicting;
- hypothesizing;
- inferring;
- defining, controlling, and manipulating variables in experimentation;
- designing, constructing, and interpreting models; and
- interpreting, analyzing, and evaluating data.

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

- 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*.

Application

Science provides the key to understanding the world in which we live. Making connections among science, technology, engineering and mathematics allows us to design and create new devices or materials that increase our efficacy in the world and our enjoyment of it. Various strategies can be used to facilitate applications of science, technology, engineering and mathematics.

Kindergarten

The kindergarten standards stress the use of basic science skills to explore common materials, objects, and living things. 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 Investigation, Reasoning, and Logic

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

a) basic ~~properties~~ characteristics of objects are identified by direct observation;

b) observations are made from multiple positions to achieve different perspectives;

~~c) objects are described both pictorially and verbally;~~ [Moved to SOL K.1k]

~~d)~~ c) a set of objects is sequenced according to size;

~~e)~~ d) a set of objects is separated into two groups based on a single physical ~~attribute~~ characteristic;

~~f)~~ e) nonstandard units are used to measure the length, mass, and volume of common objects;

~~i)~~ f) observations and predictions are made of an unseen member in a sequence of objects ~~is predicted~~;

g) a question is developed and predictions are made from one or more observations;

h) observations are recorded;

~~h)~~ i) picture graphs are constructed ~~using 10 or fewer units~~ [Move to Curriculum Framework];

j) unusual or unexpected results in an activity are recognized~~.~~; and

~~e)~~ k) objects are described both pictorially and verbally~~;~~.

K.2 The ~~S~~students ~~will~~ investigate and understand that humans have senses that allow ~~one~~ them to seek, find, take in, and react or respond to information in order to learn about ~~one's~~ their surroundings. Key concepts include

a) the five senses and corresponding sensing organs ~~(taste – tongue, touch – skin, smell – nose, hearing – ears, and sight – eyes)~~ [Move to Curriculum Framework]; and

b) sensory descriptors used to describe common objects and phenomena ~~(sweet, sour, bitter, salty, rough/smooth, hard/soft, cold, warm, hot, loud/soft, high/low, bright/dull)~~ [Move to Curriculum Framework].

Force, Motion, and Energy

K.3 The student will investigate and understand that magnets have an effect on some materials, make some things move without touching them, and have useful applications. Key concepts include

a) ~~attraction/nonattraction, push/pull, attract/repel, and metal/nonmetal~~ [Move to Curriculum Framework] magnetism and its effect; and

b) useful applications ~~(refrigerator magnet, can opener, magnetized screwdriver, and magnetic games)~~ [Move to Curriculum Framework] of magnetism.

Matter

K.4 The student will investigate and understand that the position, motion, and physical properties of an object can be described. Key concepts include

a) colors ~~(red, orange, yellow, green, blue, purple), white, and black~~ [Move to Curriculum Framework] <u>of objects</u>;

b) shapes ~~(circle, triangle, square, and rectangle)~~ [Move to Curriculum Framework] and forms ~~(flexible/stiff, straight/curved)~~ [Move to Curriculum Framework] <u>of objects</u>;

c) textures ~~(rough/smooth)~~ [Move to Curriculum Framework] and feel ~~(hard/soft)~~ [Move to Curriculum Framework] <u>of objects</u>;

d) relative size and weight ~~(big/little, large/small, heavy/light, wide/thin, long/short)~~ [Move to Curriculum Framework] <u>of objects</u>; and

e) <u>relative</u> position ~~(over/under, in/out, above/below, left/right)~~ [Move to Curriculum Framework] and speed ~~(fast/slow)~~ [Move to Curriculum Framework] <u>of objects</u>.

K.5 The student will investigate and understand that water flows and has properties that can be observed and tested. Key concepts include

a) water occurs in different ~~states~~ <u>phases</u> ~~(solid, liquid, gas)~~ [Move to Curriculum Framework];

b) ~~the natural~~ <u>water tends to</u> flow ~~of water is~~ downhill; and

c) some materials float in water, while others sink.

Life Processes

<u>K.6 The student will investigate and understand the differences between living organisms and nonliving objects. Key concepts include</u>

<u>a) all things can be classified as living or nonliving; and</u>

<u>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.</u>

~~K.6~~ <u>K.7</u> The student will investigate and understand basic needs and life processes of plants and animals. Key concepts include

a) ~~living things change as they grow, and they~~ <u>animals</u> need <u>adequate</u> food, water, <u>shelter,</u> ~~and~~ air, <u>and space</u> to survive;

~~b)~~ ~~plants and animals live and die (go through a life cycle); and~~ [Moved to SOL K.7c]

<u>b) plants need nutrients, water, air, light, and a place to grow to survive;</u>

~~c)~~ ~~offspring of plants and animals are similar but not identical to their parents and to one another.~~ [Moved to SOL K.7d]

~~b)~~ <u>c)</u> plants and animals ~~live and die (go through a~~ <u>change as they grow, and have varied</u> life cycle<u>s</u>~~)~~; and

~~c)~~ <u>d)</u> offspring of plants and animals are similar but not identical to their parents and to one another.

Interrelationships in Earth/Space Systems

~~K.7~~ <u>K.8</u> The student will investigate and understand that shadows occur when light is blocked by an object. Key concepts include

a) shadows occur in nature when sunlight is blocked by an object; and

b) shadows can be produced by blocking artificial light sources.

Earth Patterns, Cycles, and Change

~~K.8~~ K.9 The student will investigate and understand that there are simple repeating patterns in his/her daily life. Key concepts include

a) weather observations;
b) the shapes and forms of many common natural objects including seeds, cones, and leaves; and
c) animal and plant growth~~;~~. ~~and~~
~~d) home and school routines.~~

~~K.9~~ K.10 The student will investigate and understand that change occurs over time and rates may be fast or slow. Key concepts include

a) natural and human-made things may change over time; and
b) changes can be ~~noted~~ observed and measured.

Earth Resources

~~K.10~~ K.11 The student will investigate and understand that materials can be reused, recycled, and conserved. Key concepts include

a) materials and objects can be used over and over again;
b) everyday materials can be recycled; and
c) water and energy conservation at home and in school helps ~~preserve~~ ensure resources are available for future use.

Grade One

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

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

a) ~~differences in physical properties are observed using~~ the senses are used to observe differences in physical properties;

~~b) simple tools are used to enhance observations;~~ [Moved to SOL 1.1d]

b) observations are made from multiple positions to achieve a variety of perspectives;

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

~~d) observations and data are communicated orally and with simple graphs, pictures, written statements, and numbers;~~ [Move to SOL 1.1i]

~~b)~~ d) simple tools are used to enhance observations;

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

~~f) predictions are based on patterns of observation rather than random guesses;~~ [Moved to SOL 1.1h]

~~h)~~ f) inferences are made and conclusions are drawn about familiar objects and events~~.~~;

~~g) simple experiments are conducted to answer questions; and~~ [Moved to SOL 1.1j]

g) a question is developed from one or more observations;

~~h) inferences are made and conclusions are drawn about familiar objects and events.~~ [Moved to SOL 1.1f]

~~f)~~ h) predictions are made based on patterns of observations ~~rather than random guesses~~;

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

~~g)~~ j) simple investigations and experiments are conducted to answer questions~~;~~. ~~and~~

Force, Motion, and Energy

1.2 The student will investigate and understand that moving objects exhibit different kinds of motion. Key concepts include

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

b) objects may vibrate and produce sound; and

c) pushes or pulls can change the movement of an object~~;~~. ~~and~~

~~d) the motion of objects may be observed in toys and in playground activities.~~ [Move to Curriculum Framework]

Matter

1.3 The student will investigate and understand how different common materials interact with water. Key concepts include

a) some liquids will separate when mixed with water, but others will not;
b) some ~~common~~ solids will dissolve in water, but others will not; and
c) some substances will dissolve more readily in hot water than in cold water.

Life Processes

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

a) plants need~~s (food~~ nutrients, air, water, light, and a place to grow~~)~~;
b) basic parts of many plants include ~~(~~seeds, roots, stems, leaves, ~~blossoms,~~ flowers, and fruits~~)~~; and
c) plants can be classified based on a variety of characteristics ~~(edible/nonedible, flowering/nonflowering, evergreen/deciduous)~~ [Move to Curriculum Framework].

1.5 The student will investigate and understand that animals, including ~~people~~ humans, have ~~life~~ basic needs and ~~specific physical~~ certain distinguishing characteristics. ~~and can be classified according to certain characteristics.~~ Key concepts include

a) ~~life~~ basic needs include adequate ~~(air,~~ food, water~~, and a suitable place to live)~~ shelter, and space (habitat);
b) some physical characteristics include ~~(~~body coverings, body shape, appendages, and methods of movement~~)~~; and
c) ~~other characteristics~~ animals can be classified according to a variety of characteristics ~~(wild/tame, water homes/land homes)~~ [Move to Curriculum Framework].

Interrelationships in Earth/Space Systems

1.6 The student will investigate and understand the basic relationships between the sun and ~~the~~ Earth. Key concepts include

a) the sun is the source of heat and light that warms the land, air, and water; and
~~b) night and day are caused by the rotation of the Earth.~~
b) the sun's relative position in the morning is east and in the late afternoon is west.

Earth Patterns, Cycles, and Change

1.7 The student will investigate and understand that weather changes from day to day and over the seasons, and that there is a ~~the~~ relationship ~~of~~ between daily and seasonal weather change~~s~~ and ~~weather to~~ the activities and life processes of plants and animals, including humans. Key concepts include ~~how temperature, light, and precipitation bring about changes in~~

~~a) plants (growth, budding, falling leaves, and wilting);~~ [Move to Curriculum Framework]
~~b) animals (behaviors, hibernation, migration, body covering, and habitat); and~~ [Move to Curriculum Framework]
~~c) people (dress, recreation, and work).~~ [Move to Curriculum Framework]
a) simple tracking of changes in temperature, light, and precipitation over time; and
b) the effects of changes in temperature, light, and precipitation on plants, animals, and humans.

Earth Resources

1.8 The student will investigate and understand that natural resources are limited. Key concepts include

a) identification of natural resources ~~(plants and animals, water, air, land, minerals, forests, and soil)~~ [Move to Curriculum Framework];

b) factors that affect air and water quality; and

c) recycling, reusing, and reducing consumption of natural resources.

Grade Two

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 ~~states~~ phases of matter, life cycles, weather patterns, and seasonal effects on plants and animals.

Scientific Investigation, Reasoning, and Logic

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

~~a)~~ ~~observation is differentiated from personal interpretation, and conclusions are drawn based on observations;~~ [Moved to SOL 2.1i]

a) observations and predictions are made and questions are formed;

b) observations are repeated to ensure accuracy;

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

~~d)~~ ~~conditions that influence a change are defined;~~ [Moved to SOL 2.1f]

~~e)~~ ~~length, volume, mass, and temperature measurements are made in metric units (centimeters, meters, liters, degrees Celsius, grams, kilograms) and standard English units (inches, feet, yards, cups, pints, quarts, gallons, degrees Fahrenheit, ounces, pounds);~~ [Moved to SOL 2.1d]

~~e)~~ d) length, volume, mass, and temperature ~~measurements are made~~ are measured in metric units ~~(centimeters, meters, liters, degrees Celsius, grams, kilograms)~~ [Move to Curriculum Framework] and standard English units ~~(inches, feet, yards, cups, pints, quarts, gallons, degrees Fahrenheit, ounces, pounds)~~ [Move to Curriculum Framework] using the proper tools;

e) time is measured using the proper tools;

~~f)~~ ~~pictures and bar graphs are constructed using numbered axes;~~ [Moved to SOL 2.1g]

~~d)~~ f) conditions that influence a change are ~~defined~~ identified and inferences are made;

~~g)~~ ~~unexpected or unusual quantitative data are recognized; and~~ [Moved to SOL 2.1h]

~~f)~~ g) data are collected and recorded, ~~pictures~~ and bar graphs are constructed using numbered axes;

~~h)~~ ~~simple physical models are constructed.~~ [Moved to SOL 2.1k]

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

~~a)~~ i) ~~observation is differentiated from personal interpretation, and~~ conclusions are drawn ~~based on observations~~;

j) observations and data are communicated with simple bar graphs, pictures, written statements, and numbers; and

~~h)~~ k) simple physical models are constructed to clarify explanations and show relationships.

Force, Motion, and Energy

2.2 The student will investigate and understand that natural and artificial magnets have certain characteristics and attract specific types of metals. Key concepts include

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

b) important applications of magnetism ~~including the magnetic compass.~~[Move to Curriculum Framework]

Matter

2.3 The student will investigate and understand basic properties of solids, liquids, and gases. Key concepts include

~~a)~~ ~~mass and volume; and~~ [Moved to SOL 2.3b]

~~b)~~ ~~processes involved with changes in matter from one state to another (condensation, evaporation, melting, and freezing).~~ [Moved to SOL 2.3c]

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

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

~~b)~~ c) ~~processes involved with~~ changes in phases of matter ~~from one state to another~~ with the addition or removal of heat ~~(condensation, evaporation, melting, and freezing)~~ [Move to Curriculum Framework].

Life Processes

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

a) ~~some animals (frogs and butterflies) undergo distinct stages during their lives, while others generally resemble their parents~~ [Move to Curriculum Framework] animal life cycles; and

b) ~~flowering plants undergo many changes, from the formation of the flower to the development of the fruit~~ [Move to Curriculum Framework] plant life cycles.

Living Systems

2.5 The student will investigate and understand that living things are part of a system. Key concepts include

a) living organisms are interdependent with their living and nonliving surroundings; ~~and~~

b) an animal's home is its habitat and a habitat includes adequate food, water, shelter or cover, and space;

~~b)~~ c) habitats change over time due to many influences~~.~~; and

d) fossils provide information about living systems that were on Earth years ago.

Interrelationships in Earth/Space Systems

2.6 The student will investigate and understand basic types, changes, and patterns of weather. Key concepts include

a) ~~temperature, wind, precipitation, drought, flood, and storms~~ [Move to Curriculum Framework] identification of common storms and weather phenomena; ~~and~~

b) the uses and importance of measuring~~.~~, ~~and~~ recording, and interpreting weather data~~.~~; and

c) the importance and uses of measuring and tracking weather data over time.

Earth Patterns, Cycles, and Change

2.7 The student will investigate and understand that weather and seasonal changes affect plants, animals, and their surroundings. Key concepts include

a) effects of weather and seasonal changes on the growth and behavior of living things ~~(migration, hibernation, camouflage, adaptation, dormancy)~~ [Move to Curriculum Framework]; and

b) weathering, ~~and~~ erosion, and deposition of ~~the~~ land surfaces.

Earth Resources

2.8 The student will investigate and understand that plants produce oxygen and food, are a source of useful products, and provide benefits in nature. Key concepts include

a) important plant products are identified and classified ~~(fiber, cotton, oil, spices, lumber, rubber, medicines, and paper)~~ [Move to Curriculum Framework];

b) the availability of plant products affects the development of a geographic area; ~~and~~

c) plants provide oxygen, homes and food for many animals ~~and prevent soil from washing away.~~; and

d) plants can prevent soil from washing away.

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, and chemical 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 ~~environments~~ 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.

Scientific Investigation, Reasoning, and Logic

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

a) ~~predictions and~~ observations are made and are repeated to ensure accuracy;

b) predictions are formulated using a variety of sources of information;

~~c) questions are developed to formulate hypotheses;~~ [Moved to SOL 3.1g]

~~b)~~ c) objects with similar characteristics or properties are classified into at least two sets and two subsets;

~~d) volume is measured to the nearest milliliter and liter;~~ [Move to SOL 3.1e]

~~k)~~ d) natural events are sequenced chronologically~~.~~;

~~e) length is measured to the nearest centimeter;~~ [Move to SOL 3.1e]

~~f) mass is measured to the nearest gram;~~ [Move to SOL 3.1e]

~~g) data are gathered, charted, and graphed (line plot, picture graph, and bar graph);~~ [Moved to SOL 3.1h]

~~h) temperature is measured to the nearest degree Celsius;~~ [Move to SOL 3.1e]

e) length, volume, mass and temperature are measured in metric and standard English units using proper tools and techniques;

~~i) time is measured to the nearest minute;~~ [Move to SOL 3.1f]

~~i)~~ f) time is measured to the nearest minute using proper tools and techniques;

~~e)~~ g) questions are developed to formulate hypotheses;

~~g)~~ h) data are gathered, charted, ~~and~~ graphed, and analyzed; ~~(line plot, picture graph, and bar graph)~~ [Move to Curriculum Framework]

i) unexpected or unusual quantitative data are recognized;

j) inferences are made and conclusions are drawn; and

~~k) natural events are sequenced chronologically.~~ [Move to SOL 3.1d]

k) data are communicated with simple graphs, pictures, and written statements.

Force, Motion, and Energy

3.2 The student will investigate and understand simple machines and their uses. Key concepts include

~~b)~~ a) ~~how simple machines~~ purpose and function of simple machines;

~~a)~~ b) types of simple machines ~~(lever, screw, pulley, wheel and axle, inclined plane, and wedge)~~; [Move to Curriculum Framework]

~~b) how simple machines function;~~ [Moved to SOL 3.2a]

c) compound machines ~~(scissors, wheelbarrow, and bicycle)~~; [Move to Curriculum Framework] and

d) examples of simple and compound machines found in the school, home, and work environments.

Matter

3.3 The student will investigate and understand that objects are made of materials that can be described by their physical properties. Key concepts include

a) objects are made of one or more materials;

~~b) materials are composed of parts that are too small to be seen without magnification; and~~ [Move to Grade 5 Curriculum Framework]

~~c) physical properties remain the same as the material is reduced in size.~~ [Moved to SOL 3.3b]

~~c)~~ b) physical properties remain the same as the material is ~~reduced~~ changed in visible size~~.~~; and

c) visible physical changes are identified.

Life Processes

3.4 The student will investigate and understand that ~~behavioral, and physical~~ adaptations allow animals to ~~respond to~~ satisfy life needs and respond to the environment. Key concepts include

a) ~~methods of gathering and storing food, finding shelter, defending themselves, and rearing young~~ [Move to Curriculum Framework] behavioral adaptations; ~~and~~

b) ~~hibernation, migration, camouflage, mimicry, instinct, and learned behavior~~ [Move to Curriculum Framework] physical adaptations;~~.~~ and

c) chemical adaptations.

Living Systems

3.5 The student will investigate and understand relationships among organisms in aquatic and terrestrial food chains. Key concepts include

a) producer, consumer, decomposer;

b) herbivore, carnivore, omnivore; and

c) predator and prey.

3.6 The student will investigate and understand that ~~environments~~ ecosystems support a diversity of plants and animals that share limited resources. Key concepts include

a) ~~water-related~~ aquatic ~~environments~~ ecosystems; ~~(pond, marshland, swamp, stream, river, and ocean environments)~~ [Move to Curriculum Framework];

b) ~~dry-land~~ terrestrial ~~environments~~ ecosystems ~~(desert, grassland, rain forest, and forest environments)~~ [Move to Curriculum Framework]; ~~and~~

c) ~~population~~ populations and ~~community~~ communities~~.~~; and

d) the human role in conserving limited resources.

Interrelationships in Earth/Space Systems

3.7 The student will investigate and understand the major components of soil, its origin, and importance to plants and animals including humans. Key concepts include

a) soil provides the support and nutrients necessary for plant growth;

b) topsoil is a natural product of subsoil and bedrock;

c) rock, clay, silt, sand, and humus are components of soils; and

d) 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~~)~~; ~~and~~

b) animal ~~and plant~~ life cycles~~.~~; and

c) plant life cycles.

3.9 The student will investigate and understand the water cycle and its relationship to life on Earth. Key concepts include

a) there are many sources of water on Earth;

~~a)~~ b) the energy from the sun drives the water cycle;

~~b)~~ c) ~~processes involved in~~ the water cycle involves several processes ~~(evaporation, condensation, precipitation)~~; [Move to Curriculum Framework]

~~c)~~ d) water is essential for living things; and

~~d)~~ e) ~~water supply and~~ water ~~conservation~~ on Earth is limited and needs to be conserved.

Earth Resources

3.10 The student will investigate and understand that natural events and human influences can affect the survival of species. Key concepts include

a) the interdependency of plants and animals;

b) the effects of human activity on the quality of air, water, and habitat;

c) the effects of fire, flood, disease, and erosion on organisms; and

d) conservation and resource renewal.

3.11 The student will investigate and understand different sources of energy. Key concepts include

a) the sun's ability to produce light and heat energy;

b) sources of energy ~~(sunlight, water, wind)~~ [Move to Curriculum Framework];

c) fossil fuels ~~(coal, oil, natural gas)~~ ~~and wood~~ [Move to Curriculum Framework]; and

d) renewable and nonrenewable energy resources.

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 ~~Relationships are investigated~~ ~~in~~ investigate the interactions among the Earth, moon, and sun. ~~and~~ 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.

Scientific Investigation, Reasoning, and Logic

4.1 The student will demonstrate an understanding of scientific 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;

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

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

~~e)~~ ~~appropriate metric measures are used to collect, record, and report data;~~

~~h)~~ e) predictions and inferences are made, and conclusions are drawn ~~based on data from picture graphs, bar graphs, and basic line graphs~~ from a variety of sources~~.~~;

f) independent and dependent variables are identified;

~~c)~~ g) ~~variables that must be held~~ constants in an experimental situation are ~~defined~~ identified;

~~b)~~ h) hypotheses are ~~formulated based on~~ developed as cause-and-effect relationships;

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

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

k) data are communicated with simple graphs, pictures, written statements, and numbers; and

l) models are constructed to clarify explanations or demonstrate relationships.

Force, Motion, and Energy

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

a) motion is described by an object's direction and speed;

b) ~~forces cause~~ 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 ~~(open/closed, parallel/series)~~ [Move to Curriculum Framework];
c) static electricity;
d) the ability of electrical energy to be transformed into heat, light, and ~~mechanical energy~~ motion;
e) simple electromagnets and magnetism; and
f) historical contributions in understanding electricity.

Life Processes

4.4 The student will investigate and understand basic plant anatomy and life processes. Key concepts include

a) the structures of typical plants ~~(leaves, stems, roots, and flowers)~~ [Move to Curriculum Framework] and the function of each structure;
b) processes and structures involved with plant reproduction ~~(pollination, stamen, pistil, sepal, embryo, spore, and seed)~~ [Move to Curriculum Framework]; and
c) photosynthesis ~~(sunlight, chlorophyll, water, carbon dioxide, oxygen, and sugar)~~ [Move to Curriculum Framework]~~; and~~.
~~d) dormancy.~~

4.5 The student will investigate and understand that adaptations allow plants to satisfy life needs and respond to the environment. Key concepts include

a) behavioral adaptations;
b) physical adaptations; and
c) chemical adaptations.

Living Systems

~~4.5~~ 4.6 The student will investigate and understand how plants~~, and~~ animals, and humans in an ecosystem interact with one another and with the nonliving ~~environment~~ components in the ecosystem. Key concepts include

~~a) behavioral and structural adaptations;~~ [Moved to new SOL 4.5]
~~b)~~ a) organization of populations, communities, and ecosystems and how they interrelate;
~~c)~~ b) flow of energy through food webs;
~~d)~~ c) habitats and niches;
~~e)~~ d) changes in an organism's niche at various stages in its life cycle~~s~~; and
~~f)~~ e) influence of human activity on ecosystems.

Interrelationships in Earth/Space Systems

~~4.6~~ 4.7 The student will investigate and understand how weather conditions and phenomena occur and can be predicted. Key concepts include

~~b)~~ a) weather phenomena ~~(fronts, clouds, and storms)~~ [Move to Curriculum Framework]~~.~~;
~~a)~~ b) weather measurements and meteorological tools ~~(air pressure – barometer, wind speed – anemometer, rainfall – rain gauge, and temperature – thermometer)~~ [Move to Curriculum Framework]; and
c) use of weather measurements and weather phenomena to make weather predictions.

Earth Patterns, Cycles, and Change

4.8 The student will investigate and understand the organization of the solar system. Key concepts include

a) the planets in the solar system;
b) the order of the planets in the solar system; and
c) the relative sizes of the planets.

~~4.7~~ 4.9 The student will investigate and understand the relationships among the Earth, moon, and sun. Key concepts include

a) the motions of the Earth, moon, and sun ~~(revolution and rotation)~~ [Move to Curriculum Framework];
b) the causes for the Earth's seasons ~~and phases of the moon~~;
c) the causes for the phases of the moon;
~~c)~~ d) the relative size, position, age, and makeup of the Earth, moon, and sun; and
~~d)~~ e) historical contributions in understanding the Earth-moon-sun system.

Earth Resources

~~4.8~~ 4.10 The student will investigate and understand important Virginia natural resources. Key concepts include

a) watersheds and water resources;
b) 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.

Scientific 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

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

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

~~c) appropriate instruments are selected and used for making quantitative observations of length, mass, volume, and elapsed time;~~

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

~~d) accurate measurements are made using basic tools (thermometer, meter stick, balance, graduated cylinder)~~ [Move list to Curriculum Framework]

d) hypotheses are formed from testable questions;

~~g)~~ e) ~~manipulated and responding~~ independent and dependent variables are identified; ~~and~~

f) constants in an experimental situation are identified;

~~e)~~ g) data are collected, recorded, analyzed and reported using ~~the appropriate~~ proper graphical representations ~~(graphs, charts, diagrams)~~ [Move to Curriculum Framework] and using metric measurements;

~~h) an understanding of the nature of science is developed and reinforced.~~

~~f)~~ h) predictions are made using patterns from data collected, and simple graphical data are ~~extrapolated~~ generated; and

i) inferences are made and conclusions are drawn.

Force, Motion, and Energy

5.2 The student will investigate and understand how sound is transmitted and how it is used ~~as a means of communication~~. Key concepts include

a) compression waves;

~~a)~~ b) vibration, compression, wavelength, ~~vibration~~, frequency, amplitude;

~~b)~~ c) the ability of different media (solids, liquids, and gases) to transmit sound; and

~~c)~~ d) uses and applications of sound waves ~~(voice, sonar, animal sounds, and musical instruments)~~ [Move to Curriculum Framework].

5.3 The student will investigate and understand basic characteristics of visible light and how it behaves. Key concepts include

a) ~~the visible spectrum and light waves~~ transverse waves;

b) the visible spectrum;

~~d)~~ c) opaque, transparent, and translucent; ~~and~~

~~c)~~ d) reflection of light from reflective surfaces ~~(mirrors)~~ [Move to Curriculum Framework]; and

~~e) historical contributions in understanding light.~~

~~b)~~ e) refraction of light through water and prisms~~;~~.

Matter

5.4 The student will investigate and understand that matter is anything that has mass, takes up space, and occurs as a solid, liquid, or gas. Key concepts include

a) distinguishing properties of each phase of matter;

~~a)~~ b) atoms~~,~~ and elements~~, molecules, and compounds~~;

~~c) the effect of heat on the states of matter.~~

c) molecules and compounds; and

~~b)~~ d) mixtures including solutions~~; and~~.

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) kingdoms of living things;~~ [Move to Curriculum Framework]

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

~~c) vascular and nonvascular plants; and~~ [Move to Curriculum Framework]

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

~~d) vertebrates and invertebrates.~~ [Move to Curriculum Framework]

Interrelationships in Earth/Space Systems

5.6 The student will investigate and understand characteristics of the ocean environment. Key concepts include

a) geological characteristics ~~(continental shelf, slope, rise)~~ [Move to Curriculum Framework];

b) physical characteristics ~~(depth, salinity, major currents)~~ [Move to Curriculum Framework]; and

c) ~~biological~~ ecological characteristics ~~(ecosystems)~~ [Move to Curriculum Framework].

Earth Patterns, Cycles, and Change

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

a) the rock cycle including identification of and transformations between rock types;

b) Earth history and fossil evidence;

c) the basic structure of the Earth's interior;

d) changes in the Earth's crust due to plate tectonics ~~(earthquakes and volcanoes)~~ [Move to Curriculum Framework];

e) weathering, ~~and~~ erosion, and deposition; and

f) human impact.

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 the 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, can predict potential consequences of actions, but cannot be used to answer all questions.

Scientific Investigation, Reasoning, and Logic

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

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

~~b)~~ ~~a classification system is developed based on multiple attributes~~; [Moved to SOL LS.1b]

~~c)~~ b) precise and approximate measurements are recorded;

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

~~e)~~ d) hypotheses are stated in ways that identify the independent ~~(manipulated)~~ and dependent ~~(responding)~~ variables;

~~f)~~ e) a method is devised to test the validity of predictions and inferences;

~~g)~~ f) one variable is manipulated over time, using many repeated trials;

~~h)~~ g) data are collected, recorded, analyzed, and reported using ~~appropriate~~ metric measurements and tools;

~~i)~~ h) data are ~~organized~~ analyzed and communicated through graphical representation ~~(graphs, charts, and diagrams)~~; [Move to Curriculum Framework]

~~j)~~ i) models and simulations are ~~designed to explain a sequence~~used to illustrate and explain phenomena and systems; and
~~an understanding of the nature of science is developed and reinforced~~. [Moved to SOL 6.1]

j) current applications are used to reinforce science concepts.

Force, Motion, and Energy

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

a) potential and kinetic energy;
b) the role of the sun in the formation of most energy sources on Earth;
c) nonrenewable energy sources ~~(fossil fuels including petroleum, natural gas, and coal)~~; [Move to Curriculum Framework]
d) renewable energy sources ~~(wood, wind, hydro, geothermal, tidal, and solar)~~; and [Move to Curriculum Framework]
e) energy transformations (~~heat/light to mechanical, chemical, and electrical energy~~). [Move to Curriculum Framework]

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

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

Matter

6.4 The student will investigate and understand that all matter is made up of atoms. Key concepts include

a) atoms ~~are made up of~~ consist of fundamental particles, including electrons, protons, and neutrons;
b) atoms of any element are alike but are different from atoms of other elements;
c) elements may be represented by chemical symbols;
d) two or more atoms ~~may be chemically combined~~ interact to form new substances, which are held together by electrical forces (bonds);
e) compounds may be represented by chemical formulas;
f) chemical equations can be used to model chemical changes; and
g) a limited number of elements comprise the largest portion of the solid Earth, living matter, the oceans, and the atmosphere.

6.5 The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include

a) water as the universal solvent;
b) the properties of water in all three ~~states~~ phases;
c) the action of water in physical and chemical weathering;
d) the ability of large bodies of water to store heat and moderate climate;
e) the origin and occurrence of water on Earth;
f) the importance of water for agriculture, power generation, and public health; and
g) the importance of protecting and maintaining water resources.

6.6 The student will investigate and understand the properties of air and the structure and dynamics of the Earth's atmosphere. Key concepts include

a) air as a mixture of gaseous elements and compounds;
b) ~~air~~ pressure, temperature, and humidity;
c) ~~how the atmosphere~~ atmospheric changes with altitude;
d) natural and human-caused changes to the atmosphere and the importance of protecting and maintaining air quality;
e) the relationship of atmospheric measures and weather conditions; and
f) basic information from weather maps, including fronts, systems, and basic measurements~~; and~~.
g) ~~the importance of protecting and maintaining air quality~~. [Moved to SOL 6.6d]

Living Systems

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

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

Interrelationships in Earth/Space Systems

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

a) the sun, moon, Earth, other planets and their moons, 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 the 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 public policy decisions relating to the environment. Key concepts include

a) management of renewable resources ~~(water, air, soil, plant life, animal life)~~; [Move to Curriculum Framework]
b) management of nonrenewable resources ~~(coal, oil, natural gas, nuclear power, mineral resources)~~; [Move to Curriculum Framework]
c) the mitigation of land-use and environmental hazards through preventive measures; and
d) 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. Inquiry skills at this level include organization and mathematical analysis of data, manipulation of variables in experiments, and identification of sources of experimental error.

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, can predict potential consequences of actions, but cannot be used to answer all questions.

LS.1 The student will ~~plan and conduct~~ demonstrate an understanding of scientific 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)~~ ~~variables are defined~~;
b) a classification system is developed based on multiple attributes;
c) ~~metric units (SI – International System of Units) are used~~ 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) ~~continuous line graphs are constructed, interpreted, and used to make predictions~~ data are organized, communicated through graphical representation, interpreted, and used to make predictions;
i) ~~interpretations from a set of data are evaluated and defended~~ patterns are identified in data and are interpreted and evaluated; and
~~j)~~ ~~an understanding of the nature of science is developed and reinforced.~~ [Moved to SOL LS.1]
j) current applications are used to reinforce life science concepts.

LS.2 The student will investigate and understand that all living things are composed of cells. Key concepts include

a) cell structure and organelles ~~(cell membrane, cell wall, cytoplasm, vacuole, mitochondrion, endoplasmic reticulum, nucleus, and chloroplast)~~; [Move to Curriculum Framework]
b) similarities and differences between plant and animal cells;
c) development of cell theory; and
d) cell division ~~(mitosis and meiosis)~~. [Move to Curriculum Framework]

LS.3 The student will investigate and understand that living things show patterns of cellular organization. Key concepts include

a) cells, tissues, organs, and systems; and

b) ~~life functions and processes of cells, tissues, organs, and systems (respiration, removal of wastes, growth, reproduction, digestion, and cellular transport)~~ patterns of cellular organization and their relationship to life processes in living things.

~~LS.4 The student will investigate and understand that the basic needs of organisms must be met in order to carry out life processes. Key concepts include~~

~~a) plant needs;~~

~~b) animal needs; and~~

~~c) factors that influence life processes.~~ [LS.4 is included in LS.3 and LS.5]

LS.~~5~~ 4 The student will investigate and understand how organisms can be classified. Key concepts include

a) the distinguishing characteristics of domains of organisms;

~~a)~~ b) the distinguishing characteristics of kingdoms of organisms;

~~b)~~ c) the distinguishing characteristics of major animal and plant phyla; and

~~c)~~ d) the characteristics ~~of the~~ that define a species.

LS.~~6~~ 5 The student will investigate and understand the basic physical and chemical processes of photosynthesis and its importance to plant and animal life. Key concepts include

a) energy transfer between sunlight and chlorophyll;

b) transformation of water and carbon dioxide into sugar and oxygen; and

c) photosynthesis as the foundation of virtually all food webs.

LS.~~7~~ 6 The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment. Key concepts include

a) the carbon, water, and nitrogen cycles;

b) interactions resulting in a flow of energy and matter throughout the system;

c) complex relationships within terrestrial, freshwater, and marine ecosystems; and

d) energy flow in food webs and energy pyramids.

LS.~~8~~ 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.~~9~~ 8 The student will investigate and understand interactions among populations in a biological community. Key concepts include

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

b) the relationship between predators and prey;

c) competition and cooperation;

d) symbiotic relationships; and

e) niches.

LS.~~10~~ 9 The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem. Key concepts include

a) differences between ecosystems and biomes;
b) characteristics of land, marine, and freshwater ecosystems; and
c) adaptations that enable organisms to survive within a specific ecosystem.

LS.~~11~~ 10 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and ~~change over time (daily, seasonal, and long-term)~~ respond to daily, seasonal, and long-term changes in their environment. Key concepts include

a) phototropism, hibernation, and dormancy;
b) factors that increase or decrease population size; and
c) eutrophication, climate changes, and catastrophic disturbances.

LS.~~12~~ 11 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include

a) food production and harvest;
b) change in habitat size, quality, or structure;
c) change in species competition;
d) population disturbances and factors that threaten or enhance species survival; and
e) environmental issues ~~(water supply, air quality, energy production, and waste management)~~. [Move to Curriculum Framework]

LS.~~13~~ 12 The student will investigate and understand that organisms reproduce and transmit genetic information to new generations. Key concepts include

a) the structure and role of DNA;
b) the function of genes and chromosomes;
c) genotypes and phenotypes;
~~d)~~ ~~factors affecting the expression of traits~~;
~~e)~~ d) characteristics that can and cannot be inherited;
~~f)~~ e) genetic engineering and its applications; and
~~g)~~ f) historical contributions and significance of discoveries related to genetics.

LS.~~14~~ 13 The student will investigate and understand that ~~organisms~~ populations of organisms change over time. Key concepts include

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

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.

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 organization and use of the periodic table; physical and chemical changes; nuclear reactions; temperature and heat; sound; light; electricity and magnetism; and work, force, and motion.

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, can predict potential consequences of actions, but cannot be used to answer all questions.

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

a) chemicals and equipment are used safely;

b) length, mass, volume, density, temperature, weight, and force are accurately measured ~~and reported using metric units (SI – International System of Units)~~;

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)~~ ~~research skills are utilized using a variety of resources;~~

~~g)~~ f) independent and dependent variables, constants, controls, and repeated trials are identified;

~~h)~~ g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted;

~~i)~~ 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;

~~j)~~ i) frequency distributions, scattergrams, line plots, and histograms are constructed and interpreted;

~~k)~~ j) valid conclusions are made after analyzing data;

~~l)~~ k) research methods are used to investigate practical problems and questions;

~~m)~~ l) experimental results are presented in appropriate written form; and

~~n)~~ ~~an understanding of the nature of science is developed and reinforced.~~ [Moved to SOL PS.1]

m) current applications of physical science concepts are used.

PS.2 The student will investigate and understand the ~~basic~~ nature of matter. Key concepts include

a) the particle theory of matter;
b) elements, compounds, mixtures, acids, bases, and salts;
c) solids, liquids, and gases;
~~d)~~ ~~characteristics of types of matter based on physical and chemical properties;~~ [Moved to SOL PS.2f]
~~e)~~ d) physical properties ~~(shape, density, solubility, odor, melting point, boiling point, color)~~; ~~and~~ [Move to Curriculum Framework]
~~f)~~ e) chemical properties ~~(acidity, basicity, combustibility, reactivity).~~; and [Move to Curriculum Framework]
f) characteristics of types of matter based on physical and chemical properties.

PS.3 The student will investigate and understand the modern and historical models of atomic structure. Key concepts include

a) the contributions of Dalton, Thomson, Rutherford, and Bohr in understanding the atom; and
b) the modern model of atomic structure.

PS.4 The student will investigate and understand the organization and use of the periodic table of elements to obtain information. Key concepts include

a) symbols, atomic number, ~~atomic mass~~ mass number, chemical families (groups), and periods;
b) classification of elements as metals, metalloids, and nonmetals; and
c) ~~simple compounds (formulas and the nature of bonding)~~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. Key concepts include

a) physical changes;
~~b)~~ ~~nuclear reactions (products of fusion and fission and the effect of these products on humans and the environment); and~~ [Moved to SOL PS.5c]
~~c)~~ b) chemical changes ~~(types of reactions, reactants, and products; and balanced equations).~~; and [Move to Curriculum Framework]
c) nuclear reactions. ~~(products of fusion and fission and the effect of these products on humans and the environment); and~~ [Move to Curriculum Framework]

PS.6 The student will investigate and understand states and forms of energy and how energy is transferred and transformed. Key concepts include

a) potential and kinetic energy;
b) mechanical, chemical, and electrical energy; and
c) ~~heat, light, and~~ sound, thermal, radiant and nuclear energy.

PS.7 The student will investigate and understand temperature scales, heat, and ~~heat~~ 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 heat transfer ~~(heat engines, thermostats, refrigeration, and heat pumps)~~. [Move to Curriculum Framework]

PS.8 The student will investigate and understand the characteristics of sound waves and ~~technological applications of~~ sound ~~waves~~. Key concepts include

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

PS.9 The student will investigate and understand the ~~nature~~ characteristics of transverse waves and ~~technological applications of~~ light. Key concepts include

a) wavelength, frequency, speed, amplitude, crest, and trough;
~~a)~~ b) the wave behavior of light ~~(reflection, refraction, diffraction, and interference)~~; [Move to Curriculum Framework]
~~b)~~ c) images formed by lenses and mirrors; ~~and~~
~~c)~~ d) the electromagnetic spectrum; and
e) technological applications of light.

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

a) speed, velocity, and acceleration;
b) Newton's laws of motion;
c) work, force, mechanical advantage, efficiency, and power; and
d) technological applications of work, force, and motion ~~(simple machines, compound machines, powered vehicles, rockets, and restraining devices)~~. [Move to Curriculum Framework]

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

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

Earth Science

The Earth Science standards connect the study of ~~the~~ Earth's composition, structure, processes, and history; its atmosphere, fresh water, and oceans; and its environment in space. The standards emphasize historical contributions in the development of scientific thought about ~~the~~ 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 ~~the~~ Earth's resources. 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, can predict potential consequences of actions, but cannot be used to answer all questions.

ES.1 The student will plan and conduct investigations in which

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

b) technologies, including computers, probeware, and ~~global positioning systems (GPS)~~ geospatial technologies, are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions;

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

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

~~d)~~ e) variables are manipulated with repeated trials; and

~~e) a scientific viewpoint is constructed and defended (the nature of science).~~

f) current applications are used to reinforce Earth science concepts.

ES.2 The student will demonstrate the nature of science and scientific reasoning and logic ~~by~~. Key concepts include

a) ~~analyzing how~~ science explains and predicts the interactions and dynamics of complex Earth systems;

b) ~~recognizing that~~ evidence is required to evaluate hypotheses and explanations;

~~c) comparing different scientific explanations for a set of observations about the Earth~~;

~~d)~~ c) ~~explaining that~~ observation and logic are essential for reaching a conclusion; and

~~e)~~ d) ~~evaluating~~ evidence is evaluated for scientific theories.

~~ES.3~~ ~~The student will investigate and understand how to read and interpret maps, globes, models, charts, and imagery. Key concepts include~~

- ~~a)~~ ~~maps (bathymetric, geologic, topographic, and weather) and star charts;~~ [Moved to SOL ES.1d and Curriculum Framework]
- ~~b)~~ ~~imagery (aerial photography and satellite images);~~ [Moved to SOL ES.1c and Curriculum Framework]
- ~~c)~~ ~~direction and measurements of distance on any map or globe; and~~ [Moved to SOL ES.1d and Curriculum Framework]
- ~~d)~~ ~~location by latitude and longitude and topographic profiles.~~ [Moved to SOL ES.1d and Curriculum Framework]

ES.~~4~~ 3 The student will investigate and understand the characteristics of ~~the~~ Earth and the solar system. Key concepts include

- a) position of ~~the~~ Earth in the solar system;
- b) sun-Earth-moon relationships (seasons, tides, and eclipses);
- c) characteristics of the sun, planets and their moons, comets, meteors, and asteroids; and
- d) the history and contributions of ~~the~~ space ~~program~~ exploration.

ES.~~5~~ 4 The student will investigate and understand how to identify major rock-forming and ore minerals based on physical and chemical properties. Key concepts include

- a) hardness, color and streak, luster, cleavage, fracture, and unique properties; and
- b) uses of minerals.

ES.~~6~~ 5 The student will investigate and understand the rock cycle as it relates to the origin and transformation of rock types and how to identify common rock types based on mineral composition and textures. Key concepts include

- a) igneous ~~(intrusive and extrusive)~~ rocks; [Move to Curriculum Framework]
- b) sedimentary ~~(clastic and chemical)~~ rocks; and [Move to Curriculum Framework]
- c) metamorphic ~~(foliated and unfoliated)~~ rocks. [Move to Curriculum Framework]

ES.~~7~~ 6 The student will investigate and understand the differences between renewable and nonrenewable resources. Key concepts include

- a) fossil fuels, minerals, rocks, water, and vegetation;
- b) advantages and disadvantages of various energy sources;
- c) resources found in Virginia; and
- ~~d)~~ ~~making informed judgments related to resource use and its effects on Earth systems; and~~
- ~~e)~~ d) environmental costs and benefits.

ES.~~8~~ 7 The student will investigate and understand geologic processes including plate tectonics. Key concepts include

~~a)~~ ~~how geologic processes are evidenced in the physiographic provinces of Virginia including the Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau;~~ [Move to Curriculum Framework]

~~b)~~ a) geologic processes ~~(faulting, folding, volcanism, metamorphism, weathering, erosion, deposition, and sedimentation)~~ [Move to Curriculum Framework]and their resulting features; and

~~c)~~ b) tectonic processes ~~(subduction, rifting and sea floor spreading, and continental collision)~~. [Move to Curriculum Framework]

ES.~~9~~ 8 The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts include

a) processes of soil development;
b) development of karst topography;
c) ~~identification of~~ relationships between groundwater zones, including saturated and unsaturated zones and the water table~~, zone of saturation, and zone of aeration~~;
d) identification of other sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle;
e) dependence on freshwater resources and the effects of human usage on water quality; and
f) identification of the major watershed systems in Virginia including the Chesapeake Bay and its tributaries.

ES.~~10~~ 9 The student will investigate and understand that many aspects of the history and evolution of ~~the~~ Earth and life can be inferred by studying rocks and fossils. Key concepts include

a) traces and remains of ancient, often extinct, life are preserved by various means in many sedimentary rocks;
b) superposition, cross-cutting relationships, index fossils, and radioactive decay are methods of dating bodies of rock;
c) absolute and relative dating have different applications but can be used together to determine the age of rocks and structures; and
d) rocks and fossils from many different geologic periods and epochs are found in Virginia.

ES.~~11~~ 10 The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include

a) physical and chemical ~~changes~~ characteristics ~~(tides, waves, currents, sea level and ice cap variations, upwelling, and salinity variations)~~; [Move to Curriculum Framework]
b) importance of environmental and geologic implications;
c) systems interactions ~~(density differences, energy transfer, weather, and climate)~~; [Move to Curriculum Framework]
d) features of the sea floor ~~(continental margins, trenches, mid-ocean ridges, and abyssal plains)~~ [Move to Curriculum Framework] as reflections of tectonic processes; and
e) economic and public policy issues concerning the oceans and the coastal zone including the Chesapeake Bay.

ES.~~12~~ 11 The student will investigate and understand the origin and evolution of the atmosphere and the interrelationship of geologic processes, biologic processes, and human activities on its composition and dynamics. Key concepts include

a) scientific evidence for atmospheric composition changes over geologic time;
b) current theories related to the effects of early life on the chemical makeup of the atmosphere;
~~c)~~ ~~comparison of the Earth's atmosphere to that of other planets;~~
~~d)~~ c) atmospheric regulation mechanisms including the effects of density differences and energy transfer; and
~~e)~~ d) potential ~~atmospheric compositional~~ changes to the atmosphere and climate due to human, biologic, and geologic activity.

ES.~~13~~ 12 The student will investigate and understand that energy transfer between the sun and ~~the~~ Earth and its atmosphere drives ~~weather and~~ climate on Earth. Key concepts include

a) observation and collection of ~~weather~~ climate data;
b) ~~prediction of weather patterns~~ history of climate change;
c) heat exchange between the ocean and the atmosphere;
~~e)~~ d) severe weather occurrences, such as tornadoes, hurricanes, and major storms; and
~~d)~~ e) weather phenomena and the factors that affect climate including radiation, conduction and convection.

ES.~~14~~ 13 The student will investigate and understand scientific concepts related to the origin and evolution of the universe. Key concepts include

~~a)~~ ~~nebulae~~;
a) cosmology including the Big Bang theory;
b) the origin and evolution of stars ~~and,~~ star systems and galaxies~~;~~.
~~c)~~ ~~stellar evolution;~~.
~~d)~~ ~~galaxies; and~~
~~e)~~ ~~cosmology including the big bang theory~~. [Moved to SOL ES.13a]

Biology

The Biology standards are designed to provide students with a detailed understanding of living systems. Emphasis continues to be placed on the skills necessary to examine alternative scientific explanations, actively conduct controlled experiments, analyze and communicate information, and gather and use information in scientific literature. The history of biological thought and the evidence that supports it are explored, providing the foundation for investigating 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. 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, can predict potential consequences of actions, but cannot be used to answer all questions.

BIO.1 The student will demonstrate an understanding of scientific reasoning, logic and the nature of science ~~will plan and conduct~~ 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 ~~and~~, communicating results, modeling concepts and simulating experimental conditions;
j) research utilizes scientific literature;
k) differentiation is made between a scientific hypothesis and theory;
l) alternative scientific explanations and models are recognized and analyzed; and
~~m) a scientific viewpoint is constructed and defended (the nature of science).~~
m) current applications of biological concepts are used.

~~BIO.2~~ ~~The student will investigate and understand the history of biological concepts. Key concepts include~~

~~a)~~ ~~evidence supporting the cell theory;~~ [Moved to SOL BIO.3a]

~~b)~~ ~~scientific explanations of the development of organisms through time (biological evolution);~~ [Moved to SOL BIO.7e]

~~c)~~ ~~evidence supporting the germ theory of infectious disease;~~ [Moved to SOL BIO.4f]

~~d)~~ ~~development of the structural model of DNA; and~~ [Moved to SOL BIO.5e]

~~e)~~ ~~the collaborative efforts of scientists, past and present.~~

BIO.~~3~~ 2 The student will investigate and understand the chemical and biochemical principles essential for life. Key concepts include

a) water chemistry and its impact on life processes;

b) the structure and function of macromolecules;

c) the nature of enzymes; and

d) the capture, storage, transformation, and flow of energy through the processes of photosynthesis and respiration.

BIO.~~4~~ 3 The student will investigate and understand relationships between cell structure and function. Key concepts include

a) evidence supporting the cell theory;

~~a)~~ b) characteristics of prokaryotic and eukaryotic cells;

~~b)~~ ~~exploring the diversity and variation of eukaryotes;~~

c) similarities between the activities of the organelles in a single cell and a whole organism; ~~and~~

d) the cell membrane model ~~(diffusion, osmosis, and active transport).~~ ; and [Move to Curriculum Framework]

e) the impact of surface area to volume ratio on cell division, material transport and other life processes.

BIO.~~5~~ 4 The student will investigate and understand life functions of ~~archaebacteria~~, ~~monerans (eubacteria), protists, fungi, plants, and animals including humans~~ archae, bacteria and eukarya. Key concepts include

~~a)~~ ~~how their structures and functions vary between and within the kingdoms.~~

~~b)~~ a) comparison of their metabolic activities;

~~c)~~ ~~analyses of their external and internal responses to the environment;~~

~~d)~~ b) maintenance of homeostasis;

c) how the structures and functions vary among and within the eukarya kingdoms of protists, fungi, plants and animals including humans;

~~e)~~ d) human health issues, human anatomy, and body systems~~, and life functions~~; ~~and~~

~~f)~~ e) how viruses compare with organisms~~.~~; and

f) evidence supporting the germ theory of infectious disease.

BIO.~~6~~ 5 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include

a) cell growth and division;
b) gamete formation;
c) cell specialization;
d) prediction of inheritance of traits based on the Mendelian laws of heredity;
e) historical development of the structural model of DNA;
~~e)~~ f) genetic variation ~~(mutation, recombination, deletions, additions to DNA)~~; [Move to Curriculum Framework]
~~f)~~ g) the structure, function, and replication of nucleic acids ~~(DNA and RNA)~~; [Move to Curriculum Framework]
~~g)~~ h) events involved in the construction of proteins;
~~h)~~ i) use, limitations, and misuse of genetic information; and
~~i)~~ j) exploration of the impact of DNA technologies.

BIO.~~7~~ 6 The student will investigate and understand bases for modern classification systems. Key concepts include

a) structural similarities among organisms;
b) fossil record interpretation;
c) comparison of developmental stages in different organisms;
d) examination of biochemical similarities and differences among organisms; and
e) systems of classification that are adaptable to new scientific discoveries.

BIO.~~8~~ 7 The student will investigate and understand how populations change through time. Key concepts include

a) evidence found in fossil records;
b) how genetic variation, reproductive strategies, and environmental pressures impact the survival of populations;
c) how natural selection leads to adaptations;
d) emergence of new species; and
e) scientific evidence and explanations for biological evolution.

BIO.~~9~~ 8 The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include

a) interactions within and among populations including carrying capacities, limiting factors, and growth curves;
b) nutrient cycling with energy flow through ecosystems;
c) succession patterns in ecosystems;
d) the effects of natural events and human activities on ecosystems; and
e) analysis of the flora, fauna, and microorganisms of Virginia ecosystems. ~~including the Chesapeake Bay and its tributaries.~~ [Move to Curriculum Framework]

Chemistry

The Chemistry standards are designed to provide students with a detailed understanding of the interaction of matter and energy. This interaction is investigated 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 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 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, can predict potential consequences of actions, but cannot be used to answer all questions.

CH.1 The student will investigate and understand that 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 (SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, dimensional analysis);
h) use of appropriate technology including computers, graphing calculators, and probeware, for gathering data ~~and~~ ,communicating results~~;~~ ~~and~~, modeling concepts and simulating experimental conditions;
i) impact of new tools and instruments on increased understanding of nano, atomic and subatomic scales;
~~i)~~ j) construction and defense of a scientific viewpoint ~~(the nature of science).~~; and
k) the use of current applications to reinforce chemistry concepts.

CH.2 The student will investigate and understand that the placement of elements on the periodic table is a function of their atomic structure. The periodic table is a tool used for the investigations of

a) average atomic mass, mass number, and atomic number;
b) isotopes, half lives, and radioactive decay;
c) mass and charge characteristics of subatomic particles;
d) families or groups;
e) series and periods;
f) trends including atomic radii, electronegativity, shielding effect, and ionization energy;
g) electron configurations~~,~~ and valence electrons~~, and oxidation numbers~~;
h) chemical and physical properties; and
i) historical and quantum models.

CH.3 The student will investigate and understand how conservation of energy and matter is expressed in chemical formulas and balanced equations. Key concepts include

a) nomenclature;
b) balancing chemical equations;
c) writing chemical formulas (molecular, structural, and empirical; and Lewis diagrams);
d) bonding types (ionic and covalent);
e) reaction types (synthesis, decomposition, single and double replacement, ~~oxidation-reduction~~, combustion, neutralization, exothermic, and endothermic); and
f) reaction rates ~~and~~, kinetics, and equilibrium. ~~(activation energy, catalysis, and degree of randomness~~). [Move to Curriculum Framework]

CH.4 The student will investigate and understand that chemical quantities ~~in a chemical reaction~~ are based on molar relationships. Key concepts include

a) Avogadro's principle and molar volume;
b) stoichiometric relationships;
~~c)~~ ~~partial pressure;~~ [Moved to SOL CH.5b]
~~d)~~ ~~gas laws;~~ [Moved to SOL CH.5b]
~~e)~~ c) solution concentrations; and
~~f)~~ ~~chemical equilibrium; and~~ [Moved to SOL CH.3f]
~~g)~~ d) 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 the phases of matter are explained by kinetic theory and forces of attraction between particles. Key concepts include

a) pressure, temperature, and volume;
b) partial pressure and gas laws;
~~b)~~ c) vapor pressure;
~~c)~~ d) phase changes;
~~d)~~ e) molar heats of fusion and vaporization;
~~e)~~ f) specific heat capacity; and
~~f)~~ g) colligative properties.

CH.6 The student will investigate and understand how basic chemical properties relate to other areas of chemistry. Key concepts include

a) organic chemistry; and

b) biochemistry.

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, ~~light,~~ electricity, fields, and non-Newtonian physics. The standards stress the practical application of physics in other areas of science and its application to technology, engineering, and mathematics. ~~and how~~ The effects of physics ~~affects~~ 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, 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. ~~in which~~ Key concepts include

a) the components of a system are defined;

b) instruments are selected and used to extend observations and measurements ~~of mass, volume, temperature, heat exchange, energy transformations, motion, fields, and electric charge~~; [Move to Curriculum Framework]

c) information is recorded and presented in an organized format;

~~d) metric units are used in all measurements and calculations;~~

~~e)~~ d) the limitations of the experimental apparatus and design are recognized;

~~f)~~ e) the limitations of measured quantities are recognized through the appropriate use of significant figures or error ranges;

~~g) data gathered from non-SI instruments are incorporated through appropriate conversions; and~~

f) models and simulations are used to visualize and explain phenomena, to make predictions from hypotheses and to interpret data; and

~~h)~~ g) appropriate technology, including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results.

PH.2 The student will investigate and understand how to analyze and interpret data. Key concepts include

a) a description of a physical problem is translated into a mathematical statement in order to find a solution;

b) relationships between physical quantities are determined using the shape of a curve passing through experimentally obtained data;

c) the slope of a linear relationship is calculated and includes appropriate units;

d) interpolated, extrapolated, and analyzed trends are used to make predictions; and

e) ~~analysis of systems employs~~ situations with vector quantities are analyzed utilizing trigonometric ~~and~~ or graphical methods.

PH.3 The student will investigate and understand how to demonstrate scientific reasoning and logic. Key concepts include

a) analysis of scientific sources to develop and refine research hypotheses;
b) analysis of how science explains and predicts relationships;
c) evaluation of evidence for scientific theories;
d) examination of how new discoveries result in modification of existing theories or establishment of new paradigms; and
e) construction and defense of a scientific viewpoint (the nature of science).

PH.4 The student will investigate and understand how applications of physics affect the world. Key concepts include

a) examples from the real world; and
b) exploration of the roles and contributions of science and technology.

PH.5 The student will investigate and understand the interrelationships among mass, distance, force, and time through mathematical and experimental processes. Key concepts include

a) linear motion;
b) uniform circular motion;
c) projectile motion;
d) Newton's laws of motion;
e) gravitation;
f) planetary motion; and
g) work, power, and energy.

PH.6 The student will investigate and understand that quantities including mass, energy, momentum, and charge are conserved. Key concepts include

a) kinetic and potential energy;
b) elastic and inelastic collisions; and
~~c)~~ ~~electric power~~. [Moved to SOL PH.13]
c) mass/energy equivalence.

~~PH.7 The student will investigate and understand properties of fluids. Key concepts include~~

~~a) density and pressure;~~
~~b) variation of pressure with depth;~~
~~c) Archimedes' principle of buoyancy;~~
~~d) Pascal's principle;~~
~~e) fluids in motion; and~~
~~f) Bernoulli's principle.~~

PH.~~8~~ 7 The student will investigate and understand that energy can be transferred and transformed to provide usable work. Key concepts include

a) transformation of energy among forms including mechanical, thermal, ~~electrical~~, gravitational, electromagnetic, chemical, and nuclear; and
b) efficiency of systems.

PH.~~9~~ 8 The student will investigate and understand ~~how to use models of transverse and longitudinal waves to interpret~~ wave phenomena. Key concepts include

a) wave characteristics ~~(period, wavelength, frequency, amplitude, and phase~~); [Move to Curriculum Framework]

b) fundamental wave processes ~~(reflection, refraction, diffraction, interference, polarization, Doppler effect)~~; and [Move to Curriculum Framework]

c) light and sound in terms of wave models.

PH.~~10~~ 9 The student will investigate and understand that different frequencies and wavelengths in the electromagnetic spectrum are phenomena ranging from radio waves through visible light to gamma radiation. Key concepts include

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

b) particle nature of light; and

~~b)~~ c) current applications based on the ~~wave properties of each band~~ relative wavelengths.

~~PH.11 The student will investigate and understand, in describing optical systems, how light behaves in the fundamental processes of reflection, refraction, and image formation. Key concepts include~~

~~a) application of the laws of reflection and refraction;~~

~~b) construction and interpretation of ray diagrams;~~

~~c) development and use of mirror and lens equations; and~~

~~d) predictions of type, size, and position of real and virtual images.~~

PH.~~12~~ 10 The student will investigate and understand how to use the field concept to describe the effects of gravitational, electric, and magnetic forces. Key concepts include

a) inverse square laws (Newton's law of universal gravitation and Coulomb's law); and

b) ~~operating principles of motors, generators, transformers, and cathode ray tubes~~ technological applications.

PH.~~13~~ 11 The student will investigate and understand how to diagram ~~and~~, construct, and analyze basic electrical circuits and explain the function of various circuit components. Key concepts include

a) Ohm's law;

b) series, parallel, and combined circuits; ~~and~~

c) ~~circuit components including resistors, batteries, generators, fuses, switches, and capacitors.~~ electrical power; and

d) alternating and direct currents.

PH.~~14~~ 12 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 may include

a) wave/particle duality;
b) wave properties of matter;
c) matter/energy equivalence;
d) quantum mechanics and uncertainty;
e) relativity;
f) nuclear physics;
g) solid state physics;
h) nanotechnology;
~~h)~~ i) superconductivity; and
~~i)~~ j) radioactivity.