Virginia Science

Grades 9, 10, 11, 12

Adopted 2018

Biology

1. **The student will demonstrate an understanding of scientific and engineering practices by** BIO.1
    a. asking questions and defining problems BIO.1.A
        i. ask questions that arise from careful observation of phenomena and/or organisms, from examining models and theories, and/or to seek additional information BIO.1.A.I
        ii. determine which questions can be investigated within the scope of the school laboratory or field to determine relationships between independent and dependent variables BIO.1.A.II
        iii. generate hypotheses based on research and scientific principles BIO.1.A.III
        iv. make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated BIO.1.A.IV
    b. planning and carrying out investigations BIO.1.B
        i. individually and collaboratively plan and conduct observational and experimental investigations BIO.1.B.I
        ii. plan and conduct investigations or test design solutions in a safe and ethical manner including considerations of environmental, social, and personal effects BIO.1.B.II
        iii. determine appropriate sample size and techniques BIO.1.B.III
        iv. select and use appropriate tools and technology to collect, record, analyze, and evaluate data BIO.1.B.IV
    c. interpreting, analyzing, and evaluating data BIO.1.C
        i. construct and interpret data tables showing independent and dependent variables, repeated trials, and means BIO.1.C.I
        ii. construct, analyze, and interpret graphical displays of data BIO.1.C.II
        iii. use data in building and revising models, supporting an explanation for phenomena, or testing solutions to problems BIO.1.C.III
        iv. analyze data using tools, technologies, and/or models to make valid and reliable scientific claims or determine an optimal design solution BIO.1.C.IV
    d. constructing and critiquing conclusions and explanations BIO.1.D
        i. make quantitative and/or qualitative claims regarding the relationship between dependent and independent variables BIO.1.D.I
        ii. construct and revise explanations based on valid and reliable evidence obtained from a variety of sources including students' own investigations, models, theories, simulations, and peer review BIO.1.D.II
        iii. apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and design solutions BIO.1.D.III
        iv. compare and evaluate competing arguments or design solutions in light of currently accepted explanations and new scientific evidence BIO.1.D.IV

v. construct arguments or counterarguments based on data and evidence BIO.1.D.V

vi. differentiate between a scientific hypothesis and theory BIO.1.D.VI

e. developing and using models BIO.1.E

i. evaluate the merits and limitations of models BIO.1.E.I

ii. develop, revise, and/or use models based on evidence to illustrate or predict relationships BIO.1.E.II

iii. develop and/or use models to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems BIO.1.E.III

f. obtaining, evaluating, and communicating information BIO.1.F

i. compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem BIO.1.F.I

ii. gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source BIO.1.F.II

iii. communicate scientific and/or technical information about phenomena in multiple formats BIO.1.F.III

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2. **The student will investigate and understand that chemical and biochemical processes are essential for life. Key ideas include** BIO.2

a. water chemistry has an influence on life processes; BIO.2.A

b. macromolecules have roles in maintaining life processes; BIO.2.B

c. enzymes have a role in biochemical processes; BIO.2.C

d. protein synthesis is the process of forming proteins which influences inheritance and evolution; and BIO.2.D

e. the processes of photosynthesis and respiration include the capture, storage, transformation, and flow of energy. BIO.2.E

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3. **The student will investigate and understand that cells have structure and function. Key ideas include** BIO.3

a. the cell theory is supported by evidence; BIO.3.A

b. homeostasis is maintained through the role of structures in unicellular and multicellular organisms; BIO.3.B

c. cell structures and processes are involved in cell growth and division; BIO.3.C

d. the structure and function of the cell membrane support cell transport; and BIO.3.D

e. specialization leads to the development of different types of cells. BIO.3.E

4. **The student will investigate and understand that bacteria and viruses have an effect on living systems. Key ideas include** BIO.4
    a. viruses depend on a host for metabolic processes; BIO.4.A
    b. the modes of reproduction/replication can be compared; BIO.4.B
    c. the structures and functions can be compared; BIO.4.C
    d. bacteria and viruses have a role in other organisms and the environment; and BIO.4.D
    e. the germ theory of infectious disease is supported by evidence. BIO.4.E

5. **The student will investigate and understand that there are common mechanisms for inheritance. Key ideas include** BIO.5
    a. DNA has structure and is the foundation for protein synthesis; BIO.5.A
    b. the structural model of DNA has developed over time; BIO.5.B
    c. the variety of traits in an organism are the result of the expression of various combinations of alleles; BIO.5.C
    d. meiosis has a role in genetic variation between generations; and BIO.5.D
    e. synthetic biology has biological and ethical implications. BIO.5.E

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

7. **The student will investigate and understand that populations change through time. Key ideas include** BIO.7
    a. evidence is found in fossil records and through DNA analysis; BIO.7.A
    b. genetic variation, reproductive strategies, and environmental pressures affect the survival of populations; BIO.7.B
    c. natural selection is a mechanism that leads to adaptations and may lead to the emergence of new species; and BIO.7.C
    d. biological evolution has scientific evidence and explanations. BIO.7.D

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

   a. interactions within and among populations include carrying capacities, limiting factors, and growth curves; BIO.8.A

   b. nutrients cycle with energy flow through ecosystems; BIO.8.B

   c. ecosystems have succession patterns; and BIO.8.C

   d. natural events and human activities influence local and global ecosystems and may affect the flora and fauna of Virginia. BIO.8.D

Chemistry

1. **The student will demonstrate an understanding of scientific and engineering practices by** CH.1
    a. asking questions and defining problems CH.1.A
        i. ask questions that arise from careful observation of phenomena, examination of a model or theory, unexpected results, and/or to seek additional information CH.1.A.I
        ii. determine which questions can be investigated within the scope of the school laboratory CH.1.A.II
        iii. make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated CH.1.A.III
        iv. generate hypotheses based on research and scientific principles CH.1.A.IV
        v. define design problems that involve the development of a process or system with interacting components, criteria and constraints CH.1.A.V
    b. planning and carrying out investigations CH.1.B
        i. individually and collaboratively plan and conduct observational and experimental investigations CH.1.B.I
        ii. plan and conduct investigations or test design solutions in a safe manner, including planning for response to emergency situations CH.1.B.II
        iii. select and use appropriate tools and technology to collect, record, analyze, and evaluate data CH.1.B.III
    c. interpreting, analyzing and evaluating data CH.1.C
        i. record and present data in an organized format that communicates relationships and quantities in appropriate mathematical or algebraic forms CH.1.C.I
        ii. use data in building and revising models, supporting explanations for phenomena, or testing solutions to problems CH.1.C.II
        iii. solve problems using mathematical manipulations including the International System of Units (SI), scientific notation, derived units, significant digits, and dimensional analysis CH.1.C.III
        iv. analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution CH.1.C.IV
        v. analyze data graphically and use graphs to make predictions CH.1.C.V
        vi. differentiate between accuracy and precision of measurements CH.1.C.VI
        vii. consider limitations of data analysis when analyzing and interpreting data CH.1.C.VII
        viii. analyze data to optimize a design CH.1.C.VIII
    d. constructing and critiquing conclusions and explanations CH.1.D
        i. construct and revise explanations based on valid and reliable evidence obtained from a variety of sources CH.1.D.I

ii. apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena or design solutions CH.1.D.II

iii. compare and evaluate competing arguments in light of currently accepted explanations and new scientific evidence CH.1.D.III

iv. construct arguments or counterarguments based on data and evidence CH.1.D.IV

v. differentiate between scientific hypothesis, theory, and law CH.1.D.V

e. developing and using models CH.1.E

i. evaluate the merits and limitations of models CH.1.E.I

ii. develop, revise, and/or use models based on evidence to illustrate or predict relationships CH.1.E.II

iii. use models and simulations to visualize and explain the movement of particles, to represent chemical reactions, to formulate mathematical equations, and to interpret data sets CH.1.E.III

f. obtaining, evaluating, and communicating information CH.1.F

i. compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem CH.1.F.I

ii. gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source CH.1.F.II

iii. communicate scientific and/or technical information about phenomena and/or a design process in multiple formats CH.1.F.III

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2. **The student will investigate and understand that elements have properties based on their atomic structure. The periodic table is an organizational tool for elements based on these properties. Key information pertaining to the periodic table includes** CH.2

a. average atomic mass, isotopes, mass number, and atomic number; CH.2.A

b. nuclear decay; CH.2.B

c. trends within groups and periods including atomic radii, electronegativity, shielding effect, and ionization energy; CH.2.C

d. electron configurations, valence electrons, excited electrons, and ions; and CH.2.D

e. historical and quantum models. CH.2.E

3. **The student will investigate and understand that atoms are conserved in chemical reactions. Knowledge of chemical properties of the elements can be used to describe and predict chemical interactions. Key ideas include** CH.3
   a. chemical formulas are models used to represent the number of each type of atom in a substance; CH.3.A
   b. substances are named based on the number of atoms and the type of interactions between atoms; CH.3.B
   c. balanced chemical equations model rearrangement of atoms in chemical reactions; CH.3.C
   d. atoms bond based on electron interactions; CH.3.D
   e. molecular geometry is predictive of physical and chemical properties; and CH.3.E
   f. reaction types can be predicted and classified. CH.3.F

4. **The student will investigate and understand that molar relationships compare and predict chemical quantities. Key ideas include** CH.4
   a. Avogadro's principle is the basis for molar relationships; and CH.4.A
   b. stoichiometry mathematically describes quantities in chemical composition and in chemical reactions. CH.4.B

5. **The student will investigate and understand that solutions behave in predictable and quantifiable ways. Key ideas include** CH.5
   a. molar relationships determine solution concentration; CH.5.A
   b. changes in temperature can affect solubility; CH.5.B
   c. extent of dissociation defines types of electrolytes; CH.5.C
   d. pH and pOH quantify acid and base dissociation; and CH.5.D
   e. colligative properties depend on the extent of dissociation. CH.5.E

6. **The student will investigate and understand that the phases of matter are explained by the kinetic molecular theory. Key ideas include** CH.6
   a. pressure and temperature define the phase of a substance; CH.6.A
   b. properties of ideal gases are described by gas laws; and CH.6.B
   c. intermolecular forces affect physical properties. CH.6.C

7. **The student will investigate and understand that thermodynamics explains the relationship between matter and energy. Key ideas include** CH.7
    a. heat energy affects matter and interactions of matter; CH.7.A
    b. heating curves provide information about a substance; CH.7.B
    c. reactions are endothermic or exothermic; CH.7.C
    d. energy changes in reactions occur as bonds are broken and formed; CH.7.D
    e. collision theory predicts the rate of reactions; CH.7.E
    f. rates of reactions depend on catalysts and activation energy; and CH.7.F
    g. enthalpy and entropy determine the extent of a reaction. CH.7.G

Earth Science

1. **The student will demonstrate an understanding of scientific and engineering practices by** ES.1
    a. asking questions and defining problems ES.1.A
        i. ask questions that arise from careful observation of phenomena, examination of a model or theory, or unexpected results, and/or to seek additional information ES.1.A.I
        ii. determine which questions can be investigated within the scope of the school laboratory or field experience ES.1.A.II
        iii. generate hypotheses based on research and scientific principles ES.1.A.III
        iv. make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated ES.1.A.IV
        v. define design problems that involve the development of a process or system with multiple components and criteria ES.1.A.V
    b. planning and carrying out investigations ES.1.B
        i. individually and collaboratively plan and conduct observational and experimental investigations ES.1.B.I
        ii. plan and conduct investigations to test design solutions in a safe and ethical manner including considerations of environmental, social and personal effects ES.1.B.II
        iii. select and use appropriate tools and technology to collect, record, analyze, and evaluate data ES.1.B.III
    c. interpreting, analyzing, and evaluating data ES.1.C
        i. construct and interpret data tables showing independent and dependent variables, repeated trials, and means ES.1.C.I
        ii. construct, analyze, and interpret graphical displays of data and consider limitations of data analysis ES.1.C.II
        iii. apply mathematical concepts and processes to scientific questions ES.1.C.III
        iv. use data in building and revising models, supporting explanations of phenomena, or testing solutions to problems ES.1.C.IV
        v. analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims or determine an optimal design solution ES.1.C.V
    d. constructing and critiquing conclusions and explanations ES.1.D
        i. make quantitative and/or qualitative claims based on data ES.1.D.I
        ii. construct and revise explanations based on valid and reliable evidence obtained from a variety of sources, including students' own investigations, models, theories, simulations, and peer review ES.1.D.II
        iii. apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena or design solutions ES.1.D.III
        iv. construct arguments or counterarguments based on data and evidence ES.1.D.IV

v. differentiate between a scientific hypothesis, theory, and law ES.1.D.V

e. developing and using models ES.1.E

i. evaluate the merits and limitations of models ES.1.E.I

ii. develop, revise, and/or use models based on evidence to illustrate or predict relationships ES.1.E.II

iii. construct and interpret scales, diagrams, classification charts, graphs, tables, imagery, models, including geologic cross sections and topographic profiles ES.1.E.III

iv. read and interpret topographic and basic geologic maps and globes, including location by latitude and longitude ES.1.E.IV

f. obtaining, evaluating, and communicating information ES.1.F

i. compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem ES.1.F.I

ii. gather, read, and evaluate scientific and/or technical information from multiple sources, assessing the evidence and credibility of each source ES.1.F.II

iii. communicate scientific and/or technical information about phenomena and/or a design process in multiple formats ES.1.F.III

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

a. the big bang theory explains the origin of universe; ES.2.A

b. stars, star systems, and galaxies change over long periods of time; ES.2.B

c. characteristics of the sun, planets and their moons, comets, meteors, asteroids, and dwarf planets are determined by materials found in each body; and ES.2.C

d. evidence from space exploration has increased our understanding of the structure and nature of our universe. ES.2.D

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3. **The student will investigate and understand that Earth is unique in our solar system. Key ideas include** ES.3

a. Earth supports life because of its relative proximity to the sun and other factors; and ES.3.A

b. the dynamics of the sun-Earth-moon system cause seasons, tides, and eclipses. ES.3.B

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4. **The student will investigate and understand that there are major rock-forming and ore minerals. Key ideas include** ES.4

a. analysis of physical and chemical properties supports mineral identification; ES.4.A

b. characteristics of minerals determine the uses of minerals; and ES.4.B

c. minerals originate and are formed in specific ways. ES.4.C

5. **The student will investigate and understand that igneous, metamorphic, and sedimentary rocks can transform. Key ideas include** ES.5
   a. Earth materials are finite and are transformed over time; ES.5.A
   b. the rock cycle models the transformation of rocks; ES.5.B
   c. layers of Earth have rocks with specific chemical and physical properties; and ES.5.C
   d. plate tectonic and surface processes transform Earth materials. ES.5.D

6. **The student will investigate and understand that resource use is complex. Key ideas include** ES.6
   a. global resource use has environmental liabilities and benefits; ES.6.A
   b. availability, renewal rates, and economic effects are considerations when using resources; ES.6.B
   c. use of Virginia resources has an effect on the environment and the economy; and ES.6.C
   d. all energy sources have environmental and economic effects. ES.6.D

7. **The student will investigate and understand that plate tectonic theory explains Earth's internal and external geologic processes. Key ideas include** ES.7
   a. convection currents in Earth's interior lead to the movement of plates and influence the distribution of materials in Earth's layers, and may impact the magnetic field; ES.7.A
   b. features and processes occur within plates and at plate boundaries; ES.7.B
   c. interaction between tectonic plates causes the development of mountain ranges and ocean basins; and ES.7.C
   d. evidence of geologic processes is found in Virginia's geologic landscape. ES.7.D

8. **The student will investigate and understand that freshwater resources influence and are influenced by geologic processes and human activity. Key ideas include** ES.8
   a. water influences geologic processes including soil development and karst topography; ES.8.A
   b. the nature of materials in the subsurface affect the water table and future availability of fresh water; ES.8.B
   c. weather and human usage affect freshwater resources, including water locations, quality, and supply; and ES.8.C
   d. stream processes and dynamics affect the major watershed systems in Virginia, including the Chesapeake Bay and its tributaries. ES.8.D

9. **The student will investigate and understand that many aspects of the history and evolution of Earth and life can be inferred by studying rocks and fossils. Key ideas include** ES.9
    a. traces and remains of ancient, often extinct, life are preserved by various means in sedimentary rocks; ES.9.A
    b. superposition, cross-cutting relationships, index fossils, and radioactive decay are methods of dating rocks and Earth events and processes; ES.9.B
    c. absolute (radiometric) and relative dating have different applications but can be used together to determine the age of rocks and structures; and ES.9.C
    d. rocks and fossils from many different geologic periods and epochs are found in Virginia. ES.9.D

10. **The student will investigate and understand that oceans are complex, dynamic systems and are subject to long- and short-term variations. Key ideas include** ES.10
    a. chemical, biological, and physical changes affect the oceans; ES.10.A
    b. environmental and geologic occurrences affect ocean dynamics; ES.10.B
    c. unevenly distributed heat in the oceans drives much of Earth's weather; ES.10.C
    d. features of the sea floor reflect tectonic and other geological processes; and ES.10.D
    e. human actions, including economic and public policy issues, affect oceans and the coastal zone including the Chesapeake Bay. ES.10.E

11. **The student will investigate and understand that the atmosphere is a complex, dynamic system and is subject to long-and short-term variations. Key ideas include** ES.11
    a. the composition of the atmosphere is critical to most forms of life; ES.11.A
    b. biologic and geologic interactions over long and short time spans change the atmospheric composition; ES.11.B
    c. natural events and human actions may stress atmospheric regulation mechanisms; and ES.11.C
    d. human actions, including economic and policy decisions, affect the atmosphere. ES.11.D

12. **The student will investigate and understand that Earth's weather and climate are the result of the interaction of the sun's energy with the atmosphere, oceans, and the land. Key ideas include** ES.12

    a. weather involves the reflection, absorption, storage, and redistribution of energy over short to medium time spans; ES.12.A

    b. weather patterns can be predicted based on changes in current conditions; ES.12.B

    c. extreme imbalances in energy distribution in the oceans, atmosphere, and the land may lead to severe weather conditions; ES.12.C

    d. models based on current conditions are used to predict weather phenomena; and ES.12.D

    e. changes in the atmosphere and the oceans due to natural and human activity affect global climate. ES.12.E

Physics

1. **The student will demonstrate an understanding of scientific and engineering practices by.** PH.1
    a. asking questions and defining problems PH.1.A
        i. ask questions that arise from careful observation of phenomena, examination of a model or theory, unexpected results, and/or to seek additional information PH.1.A.I
        ii. determine which questions can be investigated within the scope of the school laboratory PH.1.A.II
        iii. make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated PH.1.A.III
        iv. generate hypotheses based on research and scientific principles PH.1.A.IV
        v. define design problems that involves the development of a process or system with interacting components and criteria and constraints PH.1.A.V
    b. planning and carrying out investigations PH.1.B
        i. individually and collaboratively plan and conduct observational and experimental investigations PH.1.B.I
        ii. plan and conduct investigations or test design solutions in a safe manner PH.1.B.II
        iii. select and use appropriate tools and technology to collect, record, analyze, and evaluate data PH.1.B.III
    c. interpreting, analyzing, and evaluating data PH.1.C
        i. record and present data in an organized format that communicates relationships and quantities in appropriate mathematical or algebraic forms PH.1.C.I
        ii. use data in building and revising models, supporting an explanation for phenomena, or testing solutions to problems PH.1.C.II
        iii. analyze data using tools, technologies, and/or models (e.g., computational, mathematical, statistical) in order to make valid and reliable scientific claims or determine an optimal design solution PH.1.C.III
        iv. analyze data graphically and use graphs to make predictions PH.1.C.IV
        v. consider limitations of data analysis when analyzing and interpreting data PH.1.C.V
        vi. evaluate the effects of new data on a working explanation and/or model of a proposed process or system PH.1.C.VI
        vii. analyze data to optimize a design PH.1.C.VII
    d. constructing and critiquing conclusions and explanations PH.1.D
        i. make quantitative and/or qualitative claims based on data PH.1.D.I
        ii. construct and revise explanations based on valid and reliable evidence obtained from a variety of sources PH.1.D.II

iii. apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena or design solutions PH.1.D.III

iv. compare and evaluate competing arguments in light of currently accepted explanations and new scientific evidence PH.1.D.IV

v. construct arguments or counterarguments based on data and evidence PH.1.D.V

vi. differentiate between scientific hypothesis, theory, and law PH.1.D.VI

e. developing and using models PH.1.E

i. evaluate the merits and limitations of models PH.1.E.I

ii. identify and communicate components of a system orally, graphically, textually, and mathematically PH.1.E.II

iii. develop and/or use models (including mathematical and computational) and simulations to visualize, explain, and predict phenomena and to interpret data sets PH.1.E.III

f. obtaining, evaluating, and communicating information PH.1.F

i. compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem PH.1.F.I

ii. gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source PH.1.F.II

iii. communicate scientific and/or technical information about phenomena and/or a design process in multiple formats PH.1.F.III

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2. **The student will investigate and understand, through mathematical and experimental processes, that there are relationships between position and time. Key topics include** PH.2

a. displacement, velocity, and uniform acceleration; PH.2.A

b. linear motion; PH.2.B

c. uniform circular motion; and PH.2.C

d. projectile motion. PH.2.D

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3. **The student will investigate and understand, through mathematical and experimental processes, that there are relationships among force, mass, and acceleration. Key laws include** PH.3

a. Newton's Laws of Motion; and PH.3.A

b. Newton's Law of Universal Gravitation. PH.3.B

4. **The student will investigate and understand, through mathematical and experimental processes, that conservation laws govern all interactions. Key ideas include** PH.4
   a. momentum is conserved unless an impulse acts on the system; and PH.4.A
   b. mechanical energy is conserved unless work is done on, by, or within the system. PH.4.B

5. **The student will investigate and understand, through mathematical and experimental processes, that waves transmit energy and move in predictable patterns. Key ideas include** PH.5
   a. waves have specific characteristics; PH.5.A
   b. wave interactions are part of everyday experiences; and PH.5.B
   c. light and sound can be modeled as waves. PH.5.C

6. **The student will investigate and understand, through mathematical and experimental processes, that optical systems form a variety of images. Key ideas include** PH.6
   a. the laws of reflection and refraction describe light behavior; and PH.6.A
   b. ray diagrams model light as it travels through different media. PH.6.B

7. **The student will investigate and understand, through mathematical and experimental processes, that fields provide a unifying description of force at a distance. Key ideas include** PH.7
   a. gravitational, electric, and magnetic forces can be described using the field concept; and PH.7.A
   b. field strength diminishes with increased distance from the source. PH.7.B

8. **The student will investigate and understand, through mathematical and experimental processes, that electrical circuits are a system used to transfer energy. Key ideas include** PH.8
   a. circuit components have different functions within the system; PH.8.A
   b. Ohm's law relates voltage, current, and resistance; PH.8.B
   c. different types of circuits have different characteristics and are used for different purposes; PH.8.C
   d. electrical power is related to the elements in a circuit; and PH.8.D
   e. electrical circuits have everyday applications. PH.8.E

9. **The student will investigate and understand that extremely large and extremely small quantities are not necessarily described by the same laws as those studied in Newtonian physics. Topics, such as these listed, may be included.** PH.9

   a. wave/particle duality; PH.9.A

   b. quantum mechanics and uncertainty; PH.9.B

   c. relativity; PH.9.C

   d. nuclear physics; PH.9.D

   e. solid state physics; PH.9.E

   f. nanotechnology; PH.9.F

   g. superconductivity; PH.9.G

   h. the standard model; and PH.9.H

   i. dark matter and dark energy. PH.9.I