Pennsylvania
Science, Technology & Engineering and Environmental Literacy & Sustainability Standards (STEEL)

Grades 9, 10, 11, 12

Adopted 2022

Life Science 3.1

Structure and Function

A. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. 3.1.9-12.A

B. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. 3.1.9-12.B

C. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. 3.1.9-12.C

Growth and Development of Organisms

D. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. 3.1.9-12.D

Organization for Matter and Energy Flow in Organisms

E. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. 3.1.9-12.E

F. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. 3.1.9-12.F

G. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. 3.1.9-12.G

Information Processing

na1. Not applicable at this level. 3.1.9-12.NA1

Interdependent Relationships in Ecosystems

H. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. 3.1.9-12.H

I. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. 3.1.9-12.I

Cycles of Matter and Energy Transfer in Ecosystems

J. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. 3.1.9-12.J

K. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. 3.1.9-12.K

L. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. 3.1.9-12.L

Ecosystem Dynamics, Functioning, and Resilience

M. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. 3.1.9-12.M

N. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. 3.1.9-12.N

Social Interactions and Group Behavior

O. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. 3.1.9-12.O

Inheritance of Traits

P. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. 3.1.9-12.P

Variation of Traits

Q. Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. 3.1.9-12.Q

R. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. 3.1.9-12.R

Evidence of Common Ancestry and Diversity

S. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. 3.1.9-12.S

Natural Selection

T. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. 3.1.9-12.T

U. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. 3.1.9-12.U

Adaptation

V. Create or revise a simulation to test a solution to mitigate the adverse impacts of human activity on biodiversity. 3.1.9-12.V

W. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. 3.1.9-12.W

X. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1)increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. 3.1.9-12.X

Biodiversity and Humans

na2. Not applicable at this level. 3.1.9-12.NA2

Physical Science 3.2

Structure and Properties of Matter

A. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. 3.2.9-12.A

B. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. 3.2.9-12.B

C. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. 3.2.9-12.C

D. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. 3.2.9-12.D

Chemical Reactions

E. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. 3.2.9-12.E

F. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. 3.2.9-12.F

G. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. 3.2.9-12.G

Nuclear Processes

na1. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. 3.2.9-12.NA1

Forces and Motion

I. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. 3.2.9-12.I

J. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. 3.2.9-12.J

K. Apply scientific and engineering ideas to design, evaluate and refine a device that minimizes the force on a macroscopic object during a collision. 3.2.9-12.K

Types of Interactions

L. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. 3.2.9-12.L

M. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. 3.2.9-12.M

N. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. 3.2.9-12.N

Definitions of Energy

O. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. 3.2.9-12.O

P. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). 3.2.9-12.P

Q. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. 3.2.9-12.Q

Conservation of Energy and Energy Transfer

R. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). 3.2.9-12.R

Relationship Between Energy and Forces

S. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. 3.2.9-12.S

Energy in Chemical Processes and Everyday Life

na2. Not applicable at this level. 3.2.9-12.NA2

Wave Properties

T. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. 3.2.9-12.T

U. Evaluate questions about the advantages of using digital transmission and storage of information. 3.2.9-12.U

V. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model and that for some situations one model is more useful than the other. 3.2.9-12.V

Electromagnetic Radiation

W. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. 3.2.9-12.W

Information Technologies and Instrumentation

X. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. 3.2.9-12.X

Earth and Space Science 3.3

The Universe and Its Stars

A. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation. 3.3.9-12.A

B. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, the motion of distant galaxies, and the composition of matter in the universe. 3.3.9-12.B

C. Communicate scientific ideas about the way stars, over their life cycle, produce elements. 3.3.9-12.C

Earth and the Solar System

D. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. 3.3.9-12.D

E. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. 3.3.9-12.E

The History of Planet Earth

F. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. 3.3.9-12.F

G. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. 3.3.9-12.G

Earth Materials and Systems

H. Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems. 3.3.9-12.H

I. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. 3.3.9-12.I

Plate Tectonics and Large-Scale System Interactions

J. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. 3.3.9-12.J

The Roles of Water in Earth's Surface Processes

K. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. 3.3.9-12.K

Weather and Climate

L. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. 3.3.9-12.L

M. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. 3.3.9-12.M

S. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. 3.3.9-12.S

Biogeology

N. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. 3.3.9-12.N

Natural Resources

O. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. 3.3.9-12.O

P. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. 3.3.9-12.P

Natural Hazards

na1. Not applicable at this level. 3.3.9-12.NA1

Human Impact on Earth Systems

Q. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. 3.3.9-12.Q

R. Evaluate or refine a technological solution that reduces the impact of human activities on natural systems. 3.3.9-12.R

Environmental Literacy & Sustainability 3.4

Agricultural Systems

A. Analyze and interpret how issues, trends, technologies, and policies impact agricultural, food, and environmental systems and resources. 3.4.9-12.A

Environment and Society

B. Apply research and analytical skills to evaluate the conditions and motivations that lead to conflict, cooperation, and change among individuals, groups, and nations. 3.4.9-12.B

Watersheds and Wetlands

C. Analyze and interpret how issues, trends, technologies, and policies impact watersheds and water resources. 3.4.9-12.C

Investigating Environmental Issues

D. Apply research and analytical skills to systematically investigate environmental issues ranging from local issues to those that are regional or global in scope. 3.4.9-12.D

Environmental Experiences

E. Plan and conduct an investigation utilizing environmental data about a local environmental issue. 3.4.9-12.E

Evaluating Solutions

F. Evaluate and communicate the effect of integrated pest management practices on indoor and outdoor environments. 3.4.9-12.F

Environmental Sustainability

G. Analyze and evaluate how best resource management practices and environmental laws achieve sustainability of natural resources. 3.4.9-12.G

Environmental Stewardship

H. Design and evaluate solutions in which individuals and societies can promote stewardship in environmental quality and community well-being. 3.4.9-12.H

Environmental Justice

I. Analyze and interpret data on a regional environmental condition and its implications on environmental justice and social equity. 3.4.9-12.I

Technology & Engineering 3.5

Applying, Maintaining, and Assessing Technological Products and Systems

A. Use various approaches to communicate processes and procedures for using, maintaining, and assessing technological products and systems. 3.5.9-12.A

B. Critically assess and evaluate a technology that minimizes resource use and resulting waste to achieve a goal. 3.5.9-12.B

C. Develop a solution to a technological problem that has the least negative environmental and social impact. 3.5.9-12.C

D. Critique whether existing or proposed technologies use resources sustainably. 3.5.9-12.D

E. Evaluate how technology and engineering advancements alter human health and capabilities. 3.5.9-12.E

F. Evaluate a technological innovation that arose from a specific society's unique need or want. 3.5.9-12.F

G. Evaluate a technological innovation that was met with societal resistance impacting its development. 3.5.9-12.G

H. Evaluate ways that technology and engineering can impact individuals, society, and the environment. 3.5.9-12.H

I. (ETS) Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. 3.5.9-12.I

J. Synthesize data and analyze trends to make decisions about technological products, systems, or processes. 3.5.9-12.J

K. (ETS) Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. 3.5.9-12.K

L. Interpret laws, regulations, policies, and other factors that impact the development and use of technology. 3.5.9-12.L

M. Develop a device or system for the marketplace. 3.5.9-12.M

Design and Design Thinking in Technology and Engineering Education

N. Analyze and use relevant and appropriate design thinking processes to solve technological and engineering problems. 3.5.9-12.N

O. Apply appropriate design thinking processes to diagnose, adjust, and repair systems to ensure precise, safe, and proper functionality. 3.5.9-12.O

P. Apply a broad range of design skills to a design thinking process. 3.5.9-12.P

Q. Implement and critique principles, elements, and factors of design. 3.5.9-12.Q

R. Use a design thinking process to design an appropriate technology for use in a different culture. 3.5.9-12.R

S. Conduct research to inform intentional inventions and innovations that address specific needs and wants. 3.5.9-12.S

T (ETS). Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. 3.5.9-12.T (ETS)

U. Evaluate and define the purpose of a design. 3.5.9-12.U

V. Apply principles of human-centered design. 3.5.9-12.V

W. Optimize a design by addressing desired qualities within criteria and constraints while considering trade-offs. 3.5.9-12.W

X. Implement the best possible solution to a design using an explicit process. 3.5.9-12.X

Y. (ETS) Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. 3.5.9-12.Y

Z. Recognize and explain how their community and the world around them informs technological development and engineering design. 3.5.9-12.Z

AA. Safely apply an appropriate range of making skills to a design thinking process. 3.5.9-12.AA

Integration of Knowledge, Technologies, and Practices

BB. Assess how similarities and differences among scientific, technological, engineering, and mathematical knowledge and skills contributed to the design of a product or system. 3.5.9-12.BB

CC. Analyze how technology transfer occurs when a user applies an existing innovation developed for one function for a different purpose. 3.5.9-12.CC

DD. Develop a plan that incorporates knowledge from science, mathematics, and other disciplines to design or improve a technological product or system. 3.5.9-12.DD

EE. Connect technological and engineering progress to the advancement of other areas of knowledge and vice versa. 3.5.9-12.EE

FF. Evaluate how technology enhances opportunities for new products and services through globalization. 3.5.9-12.FF

Nature and Characteristics of Technology and Engineering

GG. Evaluate how technology and engineering have been powerful forces in reshaping the social, cultural, political, and economic landscapes throughout history. 3.5.9-12.GG

HH. Analyze how the Industrial Revolution resulted in the development of mass production, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time. 3.5.9-12.HH

II. Investigate the widespread changes that have resulted from the Information Age, which has placed emphasis on the processing and exchange of information. 3.5.9-12.II

JJ. Identify and explain how the evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools, materials, and processes. 3.5.9-12.JJ

KK. Relate how technological and engineering developments have been evolutionary, often the result of a series of refinements to basic inventions or technological knowledge. 3.5.9-12.KK

LL. Analyze the stability of a technological system and how it is influenced by all of the components in the system, especially those in the feedback loop. 3.5.9-12.LL

MM. Troubleshoot and improve a flawed system embedded within a larger technological, social, or environmental system. 3.5.9-12.MM

NN. Analyze the rate of technological and engineering development and predict future diffusion and adoption of new innovations and technologies. 3.5.9-12.NN

OO. Use project management tools, strategies, and processes in planning, organizing, and controlling work. 3.5.9-12.OO

PP. Demonstrate the use of conceptual, graphical, virtual, mathematical, and physical modeling to identify conflicting considerations before the entire system is developed and to aid in design decision making. 3.5.9-12.PP