



SOUTHERN LEHIGH SCHOOL DISTRICT

5775 Main Street
Center Valley, PA 18034

Scope and Sequence for **Biology**

Pennsylvania Long-Term Transfer Goals for Science

1. Approach science as reliable and tentative way of knowing and explaining the natural world.
2. Weigh evidence and use scientific approaches to ask questions, investigate, and make informed decisions.
3. Make and use observations to analyze relationships and patterns in order to explain phenomena, develop models, and make predictions.
4. Evaluate systems, in order to connect how form determines function and how any change to one component affects the entire system.
5. Explain how the natural and designed worlds are interrelated and the application of scientific knowledge and technology can have beneficial, detrimental, or unintended consequences.

Big Idea: All organisms are made of cells and can be characterized by common aspects of their structure and functioning.

Essential Question: How do organisms live, grow, respond to their environment, and reproduce?

NGSS Performance Expectations

HS-LS1 From Molecules to Organisms: Structures and Processes

LS1.A: Structure and Function

HS-LS1-1 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.

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

LS1.B Growth and Development of Organisms

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintain complex organisms.

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PA Academic Standards for Science

3.1.A Organisms and Cells

1. Common Characteristics of Life

3.1.10.A1 Explain the characteristics of life common to all organisms.

3.1.B.A1 Describe the common characteristics of life. Compare and contrast the cellular structures and degrees of complexity of prokaryotic and eukaryotic organisms. Explain that some structures in eukaryotic cells developed from early prokaryotic cells (e.g., mitochondria, chloroplasts)

3.1.C.A1 Explain the chemistry of metabolism.

2. Energy Flow

3.1.10.A2 Explain cell processes in terms of chemical reactions and energy changes.

3.1.B.A2 Identify the initial reactants, final products, and general purposes of photosynthesis and cellular respiration. Explain the important role of ATP in cell metabolism. Describe the relationship between photosynthesis and cellular respiration in photosynthetic organisms. Explain why many biological macromolecules such as ATP and lipids contain high energy bonds. Explain the importance of enzymes as catalysts in cell reactions. Identify how factors such as pH and temperature may affect enzyme function.

3.1.C.A2 Describe how changes in energy affect the rate of chemical reactions.

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NGSS Performance Expectations

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LS1.C Organization for Matter and Energy Flow in Organisms

HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

HS-LS1-6 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.

HS-LS-7 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.

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PA Academic Standards for Science

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3. Life Cycles

3.1.10.A3 Compare and contrast the life cycles of different organisms

3.1.B.A3 Explain how all organisms begin their life cycles as a single cell and that in multicellular organisms, successive generations of embryonic cells form by cell division.

4. Cell Cycles

3.1.10.A4 Describe the cell cycle and the process and significance of mitosis.

3.1.B.A4 Summarize the stages of the cell cycle. Examine how interactions among the different molecules in the cell cause the distinct stages of the cell cycle which can also be influenced by other signaling molecules. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction.

5. Form and Function

3.1.10.A5 Relate life processes to sub-cellular and cellular structures to their functions.

3.1.B.A5 Relate the structure of cell organelles to their function (energy capture and release, transport, waste removal, protein synthesis, movement, etc.) Explain the role of water in cell metabolism. Explain how the cell membrane functions as a regulatory structure and protective barrier for the cell. Describe transport mechanisms across the plasma membrane.

6. Organization

3.1.10.A6 Identify the advantages of multi-cellularity in organisms.

3.1.B.A6 Explain how cells differentiate in multicellular organisms.

7. Molecular Basis of Life

3.1.10.A7 Describe the relationship between the structure of organic molecules and the function they serve in living organisms. Explain how cells store and use information to guide their functions.

3.1.B.A7 Analyze the importance of carbon to the structure of biological macromolecules. Compare and contrast the functions and structures of proteins, lipids, carbohydrates, and nucleic acids. Explain the consequences of extreme changes in pH and temperature on cell proteins.

3.1.C.A7 Illustrate the formation of carbohydrates, lipids, proteins, and nucleic acids.

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3.1.10.A8 Investigate the spatial relationships of organisms’ anatomical features using specimens, models, or computer programs.

3.1.B.A8 CHANGE AND CONSTANCY Recognize that systems within cells and multicellular organisms interact to maintain homeostasis. **PATTERNS** – Demonstrate the repeating patterns that occur in biological polymers. **SYSTEMS** Describe how the unique properties of water support life.

3.1.B Genetics**1. Heredity**

3.1.10.B1 Describe how genetic information is inherited and expressed.

3.1.B.B1 Explain that the information passed from parents to offspring is transmitted by means of genes which are coded in DNA molecules. Explain the basic process of DNA replication. Describe the basic processes of transcription and translation. Explain how crossing over, jumping genes, and deletion and duplication of genes results in genetic variation. Explain how mutations can alter genetic information and the possible consequences on resultant cells.

2. Reproduction

3.1.10.B2 Explain the process of meiosis resulting in the formation of gametes. Compare and contrast the function of mitosis and meiosis.

3.1.B.B2 Describe how the process of meiosis results in the formation of haploid gametes and analyze the importance of meiosis in sexual reproduction. Compare and contrast the function of mitosis and meiosis. Illustrate that the sorting and recombining of genes in sexual reproduction results in a great variety of possible gene combinations in offspring.

3. Molecular Basis of Life

3.1.10.B3 Describe the basic structure of DNA and its function in genetic inheritance. Describe the role of DNA in protein synthesis as it relates to gene expression.

3.1.B.B3 Describe the basic structure of DNA, including the role of hydrogen bonding. Explain how the process of DNA replication results in the transmission and conservation of the genetic code. Describe how transcription and translation result in gene expression. Differentiate among the end products of replication, transcription, and translation. Cite evidence to support that the genetic code is universal.

3.1.C.B3 Describe the structure of the DNA and RNA molecules.

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Compare and contrast Mendelian and non-Mendelian patterns of inheritance

3.1.B.B5 PATTERNS- Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance. Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, codominant, sex-linked, polygenic, incomplete dominance, multiple alleles)**CONSTANCY AND CHANGE** - Explain how the processes of replication, transcription, and translation are similar in all organisms. Explain how gene actions, patterns of heredity, and reproduction of cells and organisms account for the continuity of life. **SCALE** – Demonstrate how inherited characteristics can be observed at the molecular, cellular, and organism level.**3.1.C Evolution****2. Adaptation****3.1.10.C2** Explain the role of mutations and gene recombination in changing a population of organisms.**3.1.B.C2** Describe the theory suggesting that life on Earth arose as a single primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a high diversity of single-celled organisms evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting phenotype may help, harm, or have little to no effect on the offspring's success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.**3.1.C.C2** Use molecular models to demonstrate gene mutation and recombination at the molecular level.**3.2.A Chemistry****1. Properties of Matter****3.2.C.A1** Differentiate between physical properties and chemical properties. Differentiate between pure substances and mixtures; differentiate between heterogeneous and homogeneous mixtures. Explain the relationship of an element's position on the periodic table to its atomic number, ionization energy, electronegativity, atomic size, and classification of elements. Use electro-negativity to explain the difference between polar and non polar covalent bonds.*This section continues on the next page...*

NGSS Performance Expectations

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2. Structure of Matter

3.2.C.A2 Compare the electron configuration for the first twenty elements of the periodic table. Relate the position of an element on the periodic table to its electron configuration and compare its reactivity to the reactivity of other elements in the table. Explain how atoms combine to form compounds through both ionic and covalent bonding. Predict chemical formulas based on the number of valence electrons Draw Lewis dot structures for simple molecules and ionic compounds. Predict the chemical formulas for simple ionic and molecular compounds. Use the mole concept to determine number of particles and molar mass for elements and compounds. Determine percent compositions, empirical, formulas, and molecular.

3.2.B Physics

6. Unifying Themes

3.2.P.B6 PATTERNS SCALE MODELS CONSTANCY/CHANGE Use Newton’s law of motion and gravitation to describe and predict the motion of objects ranging from atoms to the galaxies

4.1 Ecology

Energy Flow

4.1.10.C. Evaluate the efficiency of energy flow within a food web. Describe how energy is converted from one form to another as it moves through a food web (photosynthetic, geothermal).

Biology Keystone Exam

Module A – Cells and Cell Processes

BIO.A.1 Basic Biological Principles

BIO.A.1.1

Explain the characteristics common to all organisms.

BIO.A.1.1.1

Describe the characteristics of life shared by all prokaryotic and eukaryotic organisms.

BIO.A.1.2

Describe relationships between structure and function at biological levels of organization

BIO.A.1.2.1

Compare cellular structures and their function in prokaryotic and eukaryotic cells.

BIO.A.1.2.2

Describe and interpret relationships between structure and function at various levels of biological organization (i.e., organelles, cells, tissue, organs, organ systems, and multicellular organisms.)

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Biology Keystone Exam	
Module A – Cells and Cell Processes	
BIO.A.2 The Chemical Basis for Life	
BIO.A.2.1 Describe how the unique properties of water support life on Earth.	BIO.A.2.1.1 Describe the unique properties of water and how these properties support life on Earth (e.g., freezing point, high specific heat, cohesion).
BIO.A.2.2 Describe and interpret relationships between structure and function at various levels of biochemical organization (i.e., atoms, molecules, and macromolecules).	BIO.A.2.2.1 Explain how carbon is uniquely suited to form biological macromolecules.
	BIO.A.2.2.2 Describe how biological macromolecules form from monomers.
	BIO.A.2.2.3 Compare the structure and function of carbohydrates, lipids, proteins, and nucleic acids in organisms.
BIO.A.2.3 Explain how enzymes regulate biochemical reactions within a cell.	BIO.A.2.3.1 Describe the role enzymes as catalyst in regulating a specific biochemical reaction.
	BIO.A.2.3.2 Explain how factors such as pH, temperature, and concentration levels can affect enzyme function.
BIO.A.3 Bioenergetics	
BIO.A.3.1 Identify and describe the cell structures involved in processing energy.	BIO.A.3.1.1 Describe the fundamental roles of plastids (e.g., chloroplasts) and mitochondria in energy transformations.
BIO.A.3.2 Identify and describe how organisms obtain and transform energy for their life processes.	BIO.A.3.2.1 Compare the basic transformation of energy during photosynthesis and cellular respiration.
	BIO.A.3.2.2 Describe the role of ATP in biochemical reactions.
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Biology Keystone Exam	
Module A – Cells and Cell Processes	
BIO.A.4 Homeostasis and Transport	
BIO.A.4.1 Identify and describe the cell structures involved in transport of materials into, out of, and throughout a cell.	BIO.A.4.1.1 Describe how the structure of the plasma membrane allows it to function as a regulatory structure and/or protective barrier for a cell.
	BIO.A.4.1.2 Compare the mechanism that transport materials across the plasma membrane (i.e., passive transport – diffusion, osmosis, facilitated diffusion; and active transport – pumps, endocytosis, exocytosis).
	BIO.A.4.1.3 Describe how membrane-bound cellular organelles (e.g., endoplasmic reticulum, Golgi apparatus) facilitate the transport of materials within a cell.
BIO.A.4.2 Explain mechanisms that permit organisms to maintain biological balance between their internal and external environments.	BIO.A.4.2.1 Explain how organisms maintain homeostasis (e.g., thermoregulation, water regulation, oxygen regeneration).
Keystone Biology Exam	
Module B – Continuity and Unity of Life	
BIO.B.1 Cell Growth and Reproduction	
BIO.B.1.1 Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis.	BIO.B.1.1.1 Describe the events that occur during the cell cycle: interphase, nuclear division (i.e., mitosis or meiosis), cytokinesis.
	BIO.B.1.1.2 Compare the processes and outcomes of mitotic and meiotic nuclear divisions.
BIO.B.1 Cell Growth and Reproduction	
BIO.B.1.2 Explain how genetic information is inherited.	BIO.B.1.2.1 Describe how the process of DNA replication results in the transmission and/r conservation of genetic information.
	BIO.B.1.2.2 Explain the functional relationships between DNA, genes, alleles, and chromosomes and their roles in inheritance.
BIO.B.2.2 Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).	BIO.B.2.2.1 Describe how the processes of transcription and translation are similar in all organisms.
	BIO.B.2.2.2 Describe the role of ribosomes, endoplasmic reticulum, Golgi apparatus, and the nucleus in the production of specific types of proteins.

Big Idea: Organisms grow, reproduce, and perpetuate their species by obtaining necessary resources through interdependent relationships with other organisms and the physical environment.

Essential Question: How and why do organisms interact with their environment and what are the effects of these interactions?

NGSS Performance Expectations

HS-LS Ecosystems: Interactions, Energy, and Dynamics

LS2.A: Interdependent Relationships in Ecosystems

HS-LS2.1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

HS-LS2.2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

HS-LS2.3 Construct and revise an explanation based on evidence for cycling of matter and flow of energy in aerobic organisms in an ecosystem.

HS-LS2.4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

HS-LS2.5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

HS-LS2.6 Evaluate 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.

HS-LS2.7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environments and biodiversity.

LS2.D: Social Interactions and Group Behavior

HS-LS2.8 Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.

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PA Academic Standards for Science

4.1 Ecology

The Environment

4.1.10.A Examine the effects of limiting factors on population dynamics.

- Analyze possible causes of population fluctuations.
- Explain the concept of carrying capacity in an ecosystem.
- Describe how organisms become classified as threatened or endangered.
- Describe how limiting factors cause organisms to become extinct.

4.1.12.A Analyze the significance of biological diversity in an ecosystem.

- Explain how species adapt to limiting factors in an ecosystem.
- Analyze the differences between natural causes and human causes of extinction.
- Research wildlife management laws and their effects on biodiversity.

Materials Cycles

4.1.10.B Explain the consequences of interrupting natural cycles.

Energy Flow

4.1.10.C Evaluate the efficiency of energy flow within a food web. Describe how energy is converted from one form to another as it moves through a food web (photosynthetic, geothermal).

4.1.12.C Research how humans affect energy flow within an ecosystem.

- Describe the impact of industrial, agricultural, and commercial enterprises on an ecosystem.

Succession

4.1.10.E Analyze how humans influence the pattern of natural changes (e.g. primary secondary succession and desertification) in ecosystems over time.

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- Describe how topography influences the flow of water in a watershed.
- Describe how vegetation affects water runoff.
- Investigate and analyze the effects of land use on the quality of water in a watershed.

4.2.12.A Examine environmental laws related to land use management and its impact on the water quality and flow within a watershed.**Wetlands****4.2.10.B** Examine how human interactions impact wetlands and their surrounding environments.

- Describe how land use decisions affect wetlands

4.2.12.B Analyze the effects of policies and regulations at various governmental levels on wetlands and their surrounding environments.

- Examine various public policies relating to wetlands.
- Investigate the intended and unintended effects of public polices and regulations relating to wetlands.

Aquatic Ecosystems**4.2.10.C** Explain the relationship between water quality and the diversity of life in a freshwater ecosystem.

- Explain how limiting factors affect the growth and reproduction of freshwater organisms.

4.2.12.C Analyze the effects of policies and regulations at various governmental levels on water quality.

- Assess the intended and unintended effects of public polices and regulations relating to water quality.

4.3 Natural Resources**Use of Natural Resources.****4.3.12.A** Evaluate the advantages and disadvantages of using renewable and nonrenewable resources.

- Explain how consumption rate affects the sustainability of resource use.
- Evaluate the advantages and disadvantages of using renewable resources such as solar power, wind power, and biofuels.

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Availability of Natural Resources

4.3.10.B Analyze how humans manage and distribute natural resources.

- Describe the use of a natural resource with an emphasis on the environmental consequences of extracting, processing, transporting, using, and disposing of it.
- Analyze the impact of technology on the management, distribution, and disposal of natural resources.

4.5 Humans and the Environment

Integrated Pest Management

4.5.10.B Describe the impact of integrated pest management practices on the environment.

4.5.12.B Evaluate pest management using methods such as cost/benefit analysis, cumulative effects analysis, environmental impact analysis, ethical analysis, and risk analysis.

Waste Management

4.5.10.D Evaluate various methods of managing waste as related to economic, environmental, and technological factors.

Biology Keystone Exam

Module B – Continuity and Unity of Life

BIO.B.4 Ecology

BIO.B.4.1

Describe ecological levels of organization in the biosphere.

BIO.B.4.1.1

Describe the levels of ecological organization (i.e., organism, population, community, ecosystem, biome, and biosphere).

BIO.B.4.1.2

Describe characteristic biotic and abiotic components of aquatic and terrestrial ecosystems.

BIO.B.4.2

Describe interactions and relationships in an ecosystem.

BIO.B.4.2.1

Describe how energy flows through an ecosystem (e.g., food chains, food webs, energy pyramids).

BIO.B.4.2.2

Describe biotic interactions in an ecosystem (e.g., competition, predation, symbiosis).

BIO.B.4.2.3

Describe how matter recycles through an ecosystem (i.e., water cycle, carbon cycle, oxygen cycle, and nitrogen cycle).

BIO.B.4.2.4

Describe how ecosystems change in response to natural and human disturbances (e.g., climate changes, introduction of nonnative species, pollution, fires).

BIO.B.4.2.5

Describe the effects of limiting factors on population dynamics and potential species extinction

Big Idea: Heredity refers to specific mechanisms by which characteristics or traits are passed from one generation to the next via genes, and explains why offspring resemble, but are not identical, to their parents.

Essential Question: How are the characteristics of one generation passed to the next? How can individuals of the same species and even siblings have different characteristics?

NGSS Performance Expectations

HS-LS3 Heredity: Inheritance and Variation of Traits

LS3.A: Inheritance of Traits

HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instruction for characteristic traits passed from parent to offspring.

LS3.B: Variation of Traits

HS-LS3-2 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.

HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

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PA Academic Standards for Science

3.1.B Genetics

1. Heredity

3.1.B.B1 Explain that the information passed from parents to offspring is transmitted by means of genes which are coded in DNA molecules. Explain the basic process of DNA replication. Describe the basic processes of transcription and translation. Explain how crossing over, jumping genes, and deletion and duplication of genes results in genetic variation. Explain how mutations can alter genetic information and the possible consequences on resultant cells.

3.1.B.B2 Describe how the process of meiosis results in the formation of haploid gametes and analyze the importance of meiosis in sexual reproduction. Compare and contrast the function of mitosis and meiosis. Illustrate that the sorting and recombining of genes in sexual reproduction results in a great variety of possible gene combinations in offspring.

3. Molecular Basis of Life

3.1.B.B3 Describe the basic structure of DNA, including the role of hydrogen bonding. Explain how the process of DNA replication results in the transmission and conservation of the genetic code. Describe how transcription and translation result in gene expression. Differentiate among the end products of replication, transcription, and translation. Cite evidence to support that the genetic code is universal.

3.1.C.B3 Describe the structure of the DNA and RNA molecules.

4. Biotechnology

3.1.10.B4 Describe the basic structure of DNA and its function in genetic inheritance. Describe the role of DNA in protein synthesis as it relates to gene expression.

3.1.B.B4 Explain how genetic technologies have impacted the fields of medicine, forensics, and agriculture.

5. Unifying Themes

3.1.B.B5 PATTERNS- Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance. Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, codominant, sex-linked, polygenic, incomplete dominance, multiple alleles)

CONSTANCY AND CHANGE - Explain how the processes of replication, transcription, and translation are similar in all organisms. Explain how gene actions, patterns of heredity, and reproduction of cells and organisms account for the continuity of life. **SCALE** – Demonstrate how inherited characteristics can be observed at the molecular, cellular, and organism level.

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3.1.C Evolution

2. Adaptation

3.1.B.C2 Describe the theory suggesting that life on Earth arose as a single primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a high diversity of single-celled organisms evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting phenotype may help, harm, or have little to no effect on the offspring’s success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.

3.1.C.C2 Use molecular models to demonstrate gene mutation and recombination at the molecular level.

4.4 Agriculture and Society

Food and Fiber System

4.4.10.A Explain the relationships between and among the components of the food and fiber system. (i.e., production, processing, research and development, marketing, distribution, and regulations.)

4.4.12.A Research and analyze the social, political, economic, and environmental factors that affect agricultural systems.

Importance of Agriculture

4.4.10.B Analyze the effects of agriculture on a society’s economy, environment, standard of living, and foreign trade.

4.4.12.B Research and evaluate laws and policies that affect the food and fiber system.

Keystone Biology Exam

Module B – Continuity and Unity of Life

BIO.B.1 Cell Growth and Reproduction

BIO.B.1.2 Explain how genetic information is inherited.

BIO.B.1.2.2

Explain the functional relationships between DNA, genes, alleles, and chromosomes and their roles in inheritance.

BIO.B.2 Genetics

BIO.B.2.1 Compare Mendelian and non-Mendelian patterns of inheritance.

BIO.B.2.1.1

Describe and/or predict observed patterns of inheritance (i.e., dominant, recessive, co-dominance, incomplete dominance, sex-linked, polygenic, and multiple alleles).

BIO.B.2.1.2

Describe processes that can alter composition or number of chromosomes (i.e., crossing-over, nondisjunction, duplication, translocation, deletion, insertion, and inversion).

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<table border="0" style="width: 100%;"> <tr> <td style="width: 70%;">Keystone Biology Exam</td> <td style="text-align: right;">Module B – Continuity and Unity of Life</td> </tr> </table>		Keystone Biology Exam	Module B – Continuity and Unity of Life
Keystone Biology Exam	Module B – Continuity and Unity of Life		
BIO.B.2 Genetics			
BIO.B.2.2 Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).	BIO.B.2.2.1 Describe how the processes of transcription and translation are similar in all organisms.		
BIO.B.2.3 Explain how genetic information is expressed.	BIO.B.2.3.1 Describe how genetic mutations alter the DNA sequence and may or may not affect phenotype (e.g., silent, nonsense, frame-shift).		
BIO.B.2.4 Apply scientific thinking, processes, tools, and technologies in the study of genetics.	BIO.B.2.4.1 Explain how genetic engineering has impacted the fields of medicine, forensics, and agriculture (e.g., selective breeding, gene splicing, cloning, genetically modified organisms, gene therapy).		
BIO.B.3 Theory of Evolution			
BIO.B.3.3 Apply scientific thinking, processes, tools, and technologies in the study of the theory of evolution.	BIO.B.3.3.1 Distinguish between the scientific terms: hypothesis, inference, law, theory, principle, fact, and observation.		

Big Idea: Biological evolution explains both the unity and diversity of species and provides a unifying principle for the history and diversity of life on Earth.

Essential Question: How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms?

NGSS Performance Expectations

HS-LS4 Biological Evolution: Unity and Diversity

LS4.A: Evidence of Common Ancestry and Diversity

HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

LS4.B Natural Selection

HS-LS4-2 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.

HS-LS4-3 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.

LS4.C Adaptation

HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations

HS-LS4-5 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.

HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

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PA Academic Standards for Science

3.1.B Genetics

3. Molecular Basis of Life

3.1.B.B3 Describe the basic structure of DNA, including the role of hydrogen bonding. Explain how the process of DNA replication results in the transmission and conservation of the genetic code. Describe how transcription and translation result in gene expression. Differentiate among the end products of replication, transcription, and translation. Cite evidence to support that the genetic code is universal.

3.1.C Evolution

1. Natural Selection

3.1.10.C1 Explain the mechanisms of biological evolution.

3.1.B.C1 Describe species as reproductively distinct groups of organisms. Analyze the role that geographic isolation can play in speciation. Explain how evolution through natural selection can result in changes in biodiversity within a population. Describe how the degree of kinship between species can be inferred from the similarity in their DNA sequences.

2. Adaptation

3.1.B.C2 Describe the theory suggesting that life on Earth arose as a single primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a high diversity of single-celled organisms evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting phenotype may help, harm, or have little to no effect on the offspring's success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.

3. Unifying Themes

3.1.10.C3 CONSTANCY AND CHANGE Interpret data from fossil records, anatomy and physiology, and DNA studies relevant to the theory of evolution.

3.1.B.C3 CONSTANCY AND CHANGE Compare and contrast various theories of evolution. Interpret data from fossil records, anatomy, and physiology, and DNA studies relevant to the theory of evolution. PATTERNS Discuss the implications of a universal genetic code for evolution.

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*Continued...**This section continues on the next page...**Continued...***4.1 Ecology****The Environment****4.1.10.A** Examine the effects of limiting factors on population dynamics.

- Analyze possible causes of population fluctuations.
- Explain the concept of carrying capacity in an ecosystem.
- Describe how organisms become classified as threatened or endangered.
- Describe how limiting factors cause organisms to become extinct.

4.1.12.A Analyze the significance of biological diversity in an ecosystem.

- Explain how species adapt to limiting factors in an ecosystem.
- Analyze the differences between natural causes and human causes of extinction.
- Research wildlife management laws and their effects on biodiversity.

Energy Flow**4.1.12.C** Research how humans affect energy flow within an ecosystem.

- Describe the impact of industrial, agricultural, and commercial enterprises on an ecosystem.

Succession**4.1.10.E** Analyze how humans influence the pattern of natural changes (e.g. primary secondary succession and desertification) in ecosystems over time.**4.2 Watersheds and Wetlands****Watersheds****4.2.10.A** Examine the interactions between abiotic and biotic factors within a watershed.

- Describe how topography influences the flow of water in a watershed.
- Describe how vegetation affects water runoff.
- Investigate and analyze the effects of land use on the quality of water in a watershed.

4.2.12.A Examine environmental laws related to land use management and its impact on the water quality and flow within a watershed.*This section continues on the next page...*

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Wetlands

4.2.10.B Examine how human interactions impact wetlands and their surrounding environments.

- Describe how land use decisions affect wetlands

4.2.12.B Analyze the effects of policies and regulations at various governmental levels on wetlands and their surrounding environments.

- Examine various public policies relating to wetlands.
- Investigate the intended and unintended effects of public polices and regulations relating to wetlands.

Aquatic Ecosystems

4.2.10.C Explain the relationship between water quality and the diversity of life in a freshwater ecosystem.

- Explain how limiting factors affect the growth and reproduction of freshwater organisms.

4.2.12.C Analyze the effects of policies and regulations at various governmental levels on water quality.

- Assess the intended and unintended effects of public polices and regulations relating to water quality.

4.3 Natural Resources

Use of Natural Resources.

4.3.12.A Evaluate the advantages and disadvantages of using renewable and nonrenewable resources.

- Explain how consumption rate affects the sustainability of resource use.
- Evaluate the advantages and disadvantages of using renewable resources such as solar power, wind power, and biofuels.

Availability of Natural Resources

4.3.10.B Analyze how humans manage and distribute natural resources.

- Describe the use of a natural resource with an emphasis on the environmental consequences of extracting, processing, transporting, using, and disposing of it.
- Analyze the impact of technology on the management, distribution, and disposal of natural resources.

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NGSS Performance Expectations

PA Academic Standards for Science

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4.5 Humans and the Environment

Integrated Pest Management

4.5.10.B Describe the impact of integrated pest management practices on the environment.

4.5.12.B Evaluate pest management using methods such as cost/benefit analysis, cumulative effects analysis, environmental impact analysis, ethical analysis, and risk analysis.

Waste Management

4.5.10.D Evaluate various methods of managing waste as related to economic, environmental, and technological factors.

Keystone Biology Exam

Module B – Continuity and Unity of Life

BIO.B.3 Theory of Evolution

BIO.B.3.1 Explain the mechanisms of evolution.

BIO.B.3.1.1

Explain how natural selection can impact allele frequencies of a population.

BIO.B.3.1.2

Describe the factors that can contribute to the development of new species (e.g., isolation mechanisms, genetic drift, founder effect, migration).

BIO.B.3.1.3

Explain how genetic mutations may result in genotypic and phenotypic variations within a population.

BIO.B.3.2 Analyze the sources of evidence for biological evolution.

BIO.B.3.2.1

Interpret evidence supporting the theory of evolution (i.e., fossil, anatomical, physiological, embryological, biochemical, and universal genetic code).

BIO.B.3.3 Apply scientific thinking, processes, tools, and technologies in the study of the theory of evolution.

BIO.B.3.3.1

Distinguish between the scientific terms: hypothesis, inference, law, theory, principle, fact, and observation.

BIO.B.4 Ecology

BIO.B.4.2

Describe interactions and relationships in an ecosystem.

BIO.B.4.2.4

Describe how ecosystems change in response to natural and human disturbances (e.g., climate changes, introduction of nonnative species, pollution, fires).

BIO.B.4.2.5

Describe the effects of limiting factors on population dynamics and potential species extinction

Pennsylvania Inquiry and Design Practices (Grades 9-12)

Asking questions and defining problems

- Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- Ask questions to clarify and refine a model, an explanation, or an engineering problem.
- Evaluate a question to determine if it is testable and relevant.
- Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
- Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
- Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Developing and using models

- Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.
- Design a test of a model to ascertain its reliability.
- Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
- Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.
- Develop a complex model that allows for manipulation and testing of a proposed process or system.
- Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Planning and carrying out investigations

- Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
- Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
- Select appropriate tools to collect, record, analyze, and evaluate data.
- Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.
- Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

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Pennsylvania Inquiry and Design Practices (Grades 9-12)

Continued...

Constructing explanations and designing solutions

- Make a quantitative and/or qualitative claim regarding the relationship between dependent
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.
- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Analyzing and interpreting data

- 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.
- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
- Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.
- Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
- Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.
- Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Using mathematics and computational thinking

- Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
- Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
- Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
- Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model “makes sense” by comparing the outcomes with what is known about the real world.
- Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m³, acre-feet, etc.).

Engaging in argument from evidence

- Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
- Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
- Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.
- Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
- Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.
- Evaluate competing design solutions to a real- world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

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Pennsylvania Inquiry and Design Practices (Grades 9-12)

Continued...

Obtaining, evaluating, and communicating information

- Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.
- Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.
- Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
- Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Big Ideas	Essential Questions
Big Idea 1: Asking questions and defining problems are essential to developing scientific habits of mind.	What kinds of questions do scientists and engineers ask?
Big Idea 2: Scientists construct mental and conceptual models of phenomena to represent current understandings, aid in developing questions and experiments, and to communicate ideas to others.	How do scientists and engineers develop and use models?
Big Idea 3: Scientists and engineers plan and investigate the world to systematically describe it and to develop and test theories and explanations about how the world works.	What do scientists and engineers do to find out more about our world and how it functions?
Big Idea 4: Data must be presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others.	In what ways are data analyzed, interpreted, and communicated?
Big Idea 5: Mathematics enables numerical representation of variables, symbolic representation of relationships between physical entities, and prediction of outcomes.	How is mathematics utilized in doing science?
Big Idea 6: Scientific theories are developed to provide explanations about the nature of particular phenomena, predict future events, or make inferences about past events.	Why are theories valuable constructs in helping scientists understand and explain our world?
Big Idea 7: Scientists and engineers use reasoning and argumentation to make a justified claim about the world.	How do scientists and engineers communicate to others in order to advance science and engineering?
Big Idea 8: Science and engineering are ways of knowing that are represented and communicated by words, diagrams, charts, graphs, images, symbols, and mathematics.	In what ways do scientists and engineers communicate their knowledge?

Pennsylvania Core Standards for Reading in Science and Technical Subjects

Key Ideas and Details

CC.3.5.9-10.A. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

CC.3.5.9-10.B. Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

CC.3.5.9-10.C. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Craft and Structure

CC.3.5.9-10.D. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.

Integration of Knowledge and Ideas

CC.3.5.9-10.G. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

CC.3.5.9-10.H. Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

CC.3.5.9-10.I. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Range and Level of Complex Texts

CC.3.5.9-10.J. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

Pennsylvania Core Standards for Writing in Science and Technical Subjects

Text Types and Purposes

CC.3.6.9-10.A. Write arguments focused on *discipline-specific content*.

- Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.
- Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
- Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
- Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
- Provide a concluding statement or section that follows from or supports the argument presented.

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Pennsylvania Core Standards for Writing in Science and Technical Subjects

Continued...

CC.3.6.9-10.B. *

Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

- Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
- Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
- Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.
- Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
- Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
- Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing

CC.3.6.9-10.C. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

CC.3.6.9-10.D. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

CC.3.6.9-10.E. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

Research to Build and Present Knowledge

CC.3.6.9-10.H. Draw evidence from informational texts to support analysis, reflection, and research.