Fairfield Public Schools
Science Curriculum

Advanced Placement Biology

Advanced Placement Biology: Description

AP Biology is an introductory college-level biology course. Students cultivate their understanding of biology through inquiry-based investigations as they explore the following topics: evolution, cellular processes—energy and communication, genetics, information transfer, ecology, and interactions.

Standards for this course are taken from the *College Board Advanced Placement Biology course description* and are of three types:

Science Practices: The science practices enable students to establish lines of evidence and use them to develop and refine testable explanations and predictions of natural phenomena.

Big Ideas: The key concepts and related content that define the revised AP Biology course and exam are organized around a few underlying principles called the big ideas, which encompass the core scientific principles, theories and processes governing living organisms and biological systems.

Learning Objectives: Learning objectives provide clear and detailed articulation of what students should know and be able to do. Each learning objective is designed to help teachers integrate science practices with specific content, and to provide them with clear information about how students will be expected to demonstrate their knowledge and abilities.

AP Biology

Enduring Understandings

- A change in the genetic makeup of a population over time is evolution.
- Organisms are linked by lines of descent from common ancestry.
- Life continues to evolve within a changing environment.
- The origin of living systems is explained by natural processes.
- Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
- Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.
- Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.
- Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.
- Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.
- Heritable information provides for continuity of life.
- Expression of genetic information involves cellular and molecular mechanisms.
- The processing of genetic information is imperfect and is a source of genetic variation.
- Cells communicate by generating, transmitting and receiving chemical signals.
- Transmission of information results in changes within and between biological systems.
- Interactions within biological systems lead to complex properties.
- Competition and cooperation are important aspects of biological systems.
- Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Course Essential Questions

- How does the process of evolution drive the diversity and unity of life?
- How do biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis?
- How do living systems store, retrieve, transmit and respond to information essential to life processes?
- How do biological systems interact?

Course: Year-at-a Glance

Unit	Title	Unit Essential Questions
1	The process of evolution drives the diversity and unity of life.	● Why is the change in the genetic makeup of a population over time considered evolution? ● Why are organisms considered linked by lines of descent from a common ancestor? ● Why does life continue to evolve within a changing environment? ● Why are the origins of living systems explained by natural processes?
2	Biological systems utilize free energy and molecular building block to grow, to reproduce and to maintain dynamic homeostasis	● Why do the growth, reproduction, and maintenance of the organization of living systems require free energy and matter? ● Why do the growth, reproduction, and dynamic homeostasis of cells require that cells create and maintain internal environments that are different from their external environments? ● Why do organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis? ● Why are growth and dynamic homeostasis of a biological system influenced by changes in the system's environment? ● Why do many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination?
3	Living systems store, retrieve, transmit and respond to information essential to life processes	● Why does heritable information provide for the continuity of life? ● Why does the expression of genetic information involve cellular and molecular mechanisms? ● Why is the processing of genetic information imperfect and a source of genetic variation? ● Why do cells communicate by generating, transmitting and receiving chemical signals? ● Why does the transmission of information result in changes within and between biological systems?
4	Biological systems interact, and these systems and their interactions possess complex properties	● Why do interactions within biological systems lead to complex properties? ● Why are competition and cooperation important aspects of biological systems? ● Why does naturally occurring diversity among and between components within biological systems affect interactions with the environment?

AP Science Practices

Science Practice 1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.
1.1 The student can create representations and models of natural or manmade phenomena and systems in the domain.
1.2 The student can describe representations and models of natural or manmade phenomena and systems in the domain.
1.3 The student can refine representations and models of natural or manmade phenomena and systems in the domain.
1.4 The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively.
1.5 The student can re-express key elements of natural phenomena across multiple representations in the domain.
Science Practice 2: The student can use mathematics appropriately
2.1 The student can justify the selection of a mathematical routine to solve problems.
2.2 The student can apply mathematical routines to quantities that describe natural phenomena.
2.3 The student can estimate numerically quantities that describe natural phenomena.
Science Practice 3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.
3.1 The student can pose scientific questions.
3.2 The student can refine scientific questions.
3.3 The student can evaluate scientific questions.
Science Practice 4: The student can plan and implement data collection strategies appropriate to a particular scientific question.
4.1 The student can justify the selection of the kind of data needed to answer a particular scientific question.
4.2 The student can design a plan for collecting data to answer a particular scientific question.
4.3 The student can collect data to answer a particular scientific question.
4.4 The student can evaluate sources of data to answer a particular scientific question
Science Practice 5: The student can perform data analysis and evaluation of evidence.
5.1 The student can analyze data to identify patterns or relationships.
5.2 The student can refine observations and measurements based on data analysis.
5.3 The student can evaluate the evidence provided by data sets in relation to a particular scientific question.
Science Practice 6: The student can work with scientific explanations and theories.
6.1 The student can justify claims with evidence.
6.2 The student can construct explanations of phenomena based on evidence produced through scientific practices.
6.3 The student can articulate the reasons that scientific explanations and theories are refined or replaced.
6.4 The student can make claims and predictions about natural phenomena based on scientific theories and models.
6.5 The student can evaluate alternative scientific explanations.
Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts and representations in and across domains.
7.1 The student can connect phenomena and models across spatial and temporal scales.
7.2 The student can connect concepts in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

Unit 1: The Process of Evolution Drives the Diversity and Unity of Life

Overview

Evolution is a change in the genetic makeup of a population over time, with natural selection as its major driving mechanism. Naturally occurring and human induced events as well as random environmental changes can result in alteration in the gene pools of populations. A diverse gene pool is vital for the survival of species because environmental conditions change. Scientific evidence supports the idea that both speciation and extinction have occurred throughout Earth's history and that life continues to evolve within a changing environment, thus explaining the diversity of life.

Performance Expectations

At the conclusion of this unit, students will be able to evaluate why:

- Natural selection is a major mechanism of evolution.
- Natural selection acts on phenotypic variations in populations.
- Evolutionary change is also driven by random processes.
- Biological evolution is supported by scientific evidence from many disciplines, including mathematics.
- Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.
- Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.
- Speciation and extinction have occurred throughout the Earth's history.
- Speciation may occur when two populations become reproductively isolated from each other.
- Populations of organisms continue to evolve.
- There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.
- Scientific evidence from many different disciplines supports models of the origin of life.

Unit Essential Questions

- Why is the change in the genetic makeup of a population over time considered evolution?
- Why are organisms considered linked by lines of descent from a common ancestor?
- Why does life continue to evolve within a changing environment?
- Why are the origins of living systems explained by natural processes?

College Board Unit Standards

BIG IDEA:
Big Idea 1: The process of evolution drives the diversity and unity of life.

LEARNING OBJECTIVES:
LO 1.1 The student is able to convert a data set from a table of numbers that reflect a change in the genetic makeup of a population over time and to apply mathematical methods and conceptual understandings to investigate the cause(s) and effect(s) of this change. [See SP 1.5, 2.2]
LO 1.2 The student is able to evaluate evidence provided by data to qualitatively and/or quantitatively investigate the role of natural selection in evolution. [See SP 2.2, 5.3]
LO 1.3 The student is able to apply mathematical methods to data from a real or simulated population to predict what will happen to the population in the future. [See SP 2.2]
LO 1.4 The student is able to evaluate data-based evidence that describes evolutionary changes in the genetic makeup of a population over time. [See SP 5.3]
LO 1.5 The student is able to connect evolutionary changes in a population over time to a change in the environment.[See SP 7.1]
LO 1.6 The student is able to use data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and effects of selection in the evolution of specific populations. [See SP 1.4, 2.1]
LO 1.7 The student is able to justify the selection of data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and the effects of selection in the evolution of specific populations. [See SP 2.1, 4.1]
LO 1.8 The student is able to make predictions about the effects of genetic drift, migration and artificial selection on the genetic makeup of a population. [See SP 6.4]
LO 1.9 The student is able to evaluate evidence provided by data from many scientific disciplines that support biological evolution. [See SP 5.3]
LO 1.10 The student is able to refine evidence based on data from many scientific disciplines that support biological evolution. [See SP 5.2]
LO 1.11 The student is able to design a plan to answer scientific questions regarding how organisms have changed over time using information from morphology, biochemistry and geology. [See SP 4.2]
LO 1.12 The student is able to connect scientific evidence from many scientific disciplines to support the modern concept of evolution. [See SP 7.1]
LO 1.13 The student is able to construct and/or justify mathematical models, diagrams or simulations that represent processes of biological evolution. [See SP 1.1, 2.1]
LO 1.14 The student is able to pose scientific questions that correctly identify essential properties of shared, core life processes that provide insights into the history of life on Earth. [See SP 3.1]
LO 1.15 The student is able to describe specific examples of conserved core biological processes and features shared by all domains or within one domain of life, and how these shared, conserved core processes and features support the concept of common ancestry for all organisms. [See SP 7.2]
LO 1.16 The student is able to justify the scientific claim that organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. [See SP 6.1]

LO 1.17 The student is able to pose scientific questions about a group of organisms whose relatedness is described by a phylogenetic tree or cladogram in order to (1) identify shared characteristics, (2) make inferences about the evolutionary history of the group, and (3) identify character data that could extend or improve the phylogenetic tree. [See SP 3.1]
LO 1.18 The student is able to evaluate evidence provided by a data set in conjunction with a phylogenetic tree or a simple cladogram to determine evolutionary history and speciation. [See SP 5.3]
LO 1.19 The student is able create a phylogenetic tree or simple cladogram that correctly represents evolutionary history and speciation from a provided data set. [See SP 1.1]
LO 1.20 The student is able to analyze data related to questions of speciation and extinction throughout the Earth's history. [See SP 5.1]
LO 1.21 The student is able to design a plan for collecting data to investigate the scientific claim that speciation and extinction have occurred throughout the Earth's history. [See SP 4.2]
LO 1.22 The student is able to use data from a real or simulated population(s), based on graphs or models of types of selection, to predict what will happen to the population in the future. [See SP 6.4]
LO 1.23 The student is able to justify the selection of data that address questions related to reproductive isolation and speciation. [See SP 4.1]
LO 1.24 The student is able to describe speciation in an isolated population and connect it to change in gene frequency, change in environment, natural selection and/or genetic drift. [See SP 7.2]
LO 1.25 The student is able to describe a model that represents evolution within a population. [See SP 1.2]
LO 1.26 The student is able to evaluate given data sets that illustrate evolution as an ongoing process. [See SP 5.3]
LO 1.27 The student is able to describe a scientific hypothesis about the origin of life on Earth. [See SP 1.2]
LO 1.28 The student is able to evaluate scientific questions based on hypotheses about the origin of life on Earth. [See SP 3.3]
LO 1.29 The student is able to describe the reasons for revisions of scientific hypotheses of the origin of life on Earth. [See SP 6.3]
LO 1.30 The student is able to evaluate scientific hypotheses about the origin of life on Earth. [See SP 6.5]
LO 1.31 The student is able to evaluate the accuracy and legitimacy of data to answer scientific questions about the origin of life on Earth. [See SP 4.4]
LO 1.32 The student is able to justify the selection of geological, physical, and chemical data that reveal early Earth conditions. [See SP 4.1]

Unit 2: Biological systems utilize free energy & molecular building blocks to grow, to reproduce & to maintain dynamic homeostasis

Overview

Living systems require free energy and matter to maintain order, grow and reproduce. Organisms employ various strategies to capture, use and store free energy and other vital resources. Energy deficiencies are not only detrimental to individual organisms, they also can cause disruptions at the population and ecosystem level.

Performance Expectations

At the conclusion of this unit, students will be able to evaluate why:

- All living systems require constant input of free energy.
- Organisms capture and store free energy for use in biological processes.
- Organisms must exchange matter with the environment to grow, reproduce and maintain organization.
- Cell membranes are selectively permeable due to their structure.
- Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.
- Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.
- Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.
- Organisms respond to changes in their external environments.
- All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.
- Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.
- Biological systems are affected by disruptions to their dynamic homeostasis.
- Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.
- Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.
- Timing and coordination of physiological events are regulated by multiple mechanisms.
- Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.

Unit Essential Questions

- Why do the growth, reproduction, and maintenance of the organization of living systems require free energy and matter?
- Why do the growth, reproduction, and dynamic homeostasis of cells require that cells create and maintain internal environments that are different from their external environments?
- Why do organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis?
- Why are growth and dynamic homeostasis of a biological system influenced by changes in the system's environment?
- Why do many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination?

College Board Unit Standards

BIG IDEA:
Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

LEARNING OBJECTIVES:
LO 2.1 The student is able to explain how biological systems use free energy based on empirical data that all organisms require constant energy input to maintain organization, to grow, and to reproduce. [See SP 6.2]
LO 2.2 The student is able to justify a scientific claim that free energy is required for living systems to maintain organization, to grow, or to reproduce, but that multiple strategies for obtaining and using energy exist in different living systems. [See SP 6.1]
LO 2.3 The student is able to predict how changes in free energy availability affect organisms, populations, and/or ecosystems. [See SP 6.4]
LO 2.4 The student is able to use representations to pose scientific questions about what mechanisms and structural features allow organisms to capture, store and use free energy. [See SP 1.4, 3.1]
LO 2.5 The student is able to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy. [See SP 6.2]
LO 2.41 The student is able to evaluate data to show the relationship between photosynthesis and respiration in the flow of free energy through a system. [See SP 5.3, 7.1]
LO 2.6 The student is able to use calculated surface area-to-volume ratios to predict which cell(s) might eliminate wastes or procure nutrients faster by diffusion. [See SP 2.2]
LO 2.7 Students will be able to explain how cell size and shape affect the overall rate of nutrient intake and the rate of waste elimination. [See SP 6.2]
LO 2.8 The student is able to justify the selection of data regarding the types of molecules that an animal, plant or bacterium will take up as necessary building blocks and excrete as waste products. [See SP 4.1]
LO 2.9 The student is able to represent graphically or model quantitatively the exchange of molecules between an organism and its environment, and the subsequent use of these molecules to build new molecules that facilitate dynamic homeostasis, growth and reproduction. [See SP 1.1, 1.4]

LO 2.10 The student is able to use representations and models to pose scientific questions about the properties of cell membranes and selective permeability based on molecular structure. [See SP 1.4, 3.1]
LO 2.11 The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function. [See SP 1.1, 7.1, 7.2]
LO 2.12 The student is able to use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasis is maintained by the active movement of molecules across membranes. [See SP 1.4]
LO 2.13 The student is able to explain how internal membranes and organelles contribute to cell functions. [See SP 6.2]
LO 2.14 The student is able to use representations and models to describe differences in prokaryotic and eukaryotic cells. [See SP 1.2, 1.4]
LO 2.15 The student can justify a claim made about the effect(s) on a biological system at the molecular, physiological or organismal level when given a scenario in which one or more components within a negative regulatory system is altered. [See SP 6.1]
LO 2.16 The student is able to connect how organisms use negative feedback to maintain their internal environments. [See SP 7.2]
LO 2.17 The student is able to evaluate data that show the effect(s) of changes in concentrations of key molecules on negative feedback mechanisms. [See SP 5.3]
LO 2.18 The student can make predictions about how organisms use negative feedback mechanisms to maintain their internal environments. [See SP 6.4]
LO 2.19 The student is able to make predictions about how positive feedback mechanisms amplify activities and processes in organisms based on scientific theories and models. [See SP 6.4]
LO 2.20 The student is able to justify that positive feedback mechanisms amplify responses in organisms. [See SP 6.1]
LO 2.21 The student is able to justify the selection of the kind of data needed to answer scientific questions about the relevant mechanism that organisms use to respond to changes in their external environment. [See SP 4.1]
LO 2.42 The student is able to pose a scientific question concerning the behavioral or physiological response of an organism to a change in its environment. [See SP 3.1]
LO 2.22 The student is able to refine scientific models and questions about the effect of complex biotic and abiotic interactions on all biological systems, from cells and organisms to populations, communities and ecosystems. [See SP 1.3, 3.2]
LO 2.23 The student is able to design a plan for collecting data to show that all biological systems (cells, organisms, populations, communities and ecosystems) are affected by complex biotic and abiotic interactions. [See SP 4.2, 7.2]
LO 2.24 The student is able to analyze data to identify possible patterns and relationships between a biotic or abiotic factor and a biological system (cells, organisms, populations, communities or ecosystems). [See SP 5.1]
LO 2.25 The student can construct explanations based on scientific evidence that homeostatic mechanisms reflect continuity due to common ancestry and/or divergence due to adaptation in different environments. [See SP 6.2]
LO 2.26 The student is able to analyze data to identify phylogenetic patterns or relationships, showing that homeostatic mechanisms reflect both continuity due to common ancestry and change due to evolution in different environments. [See SP 5.1]
LO 2.27 The student is able to connect differences in the environment with the evolution of homeostatic mechanisms. [See SP 7.1]
LO 2.28 The student is able to use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems. [See SP 1.4]
LO 2.29 The student can create representations and models to describe immune responses. [See SP 1.1, 1.2]
LO 2.30 The student can create representations or models to describe nonspecific immune defenses in plants and animals. [See SP 1.1, 1.2]

LO 2.43 The student is able to connect the concept of cell communication to the functioning of the immune system. [See SP 7.2]
LO 2.31 The student can connect concepts in and across domains to show that timing and coordination of specific events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms. [See SP 7.2]
LO 2.32 The student is able to use a graph or diagram to analyze situations or solve problems (quantitatively or qualitatively) that involve timing and coordination of events necessary for normal development in an organism. [See SP 1.4]
LO 2.33 The student is able to justify scientific claims with scientific evidence to show that timing and coordination of several events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms. [See SP 6.1]
LO 2.34 The student is able to describe the role of programmed cell death in development and differentiation, the reuse of molecules, and the maintenance of dynamic homeostasis. [See SP 7.1]
LO 2.35 The student is able to design a plan for collecting data to support the scientific claim that the timing and coordination of physiological events involve regulation. [See SP 4.2]
LO 2.36 The student is able to justify scientific claims with evidence to show how timing and coordination of physiological events involve regulation. [See SP 6.1]
LO 2.37 The student is able to connect concepts that describe mechanisms that regulate the timing and coordination of physiological events. [See SP 7.2]
LO 2.38 The student is able to analyze data to support the claim that responses to information and communication of information affect natural selection. [See SP 5.1]
LO 2.39 The student is able to justify scientific claims, using evidence, to describe how timing and coordination of behavioral events in organisms are regulated by several mechanisms. [See SP 6.1]
LO 2.40 The student is able to connect concepts in and across domain(s) to predict how environmental factors affect responses to information and change behavior. [See SP 7.2]

Unit 3: Living systems store, retrieve, transmit and respond to information essential to life processes

Performance Expectations

At the conclusion of this unit, students will be able to evaluate why:

- DNA, and in some cases RNA, is the primary source of heritable information.
- In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.
- The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring
- The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.
- Gene regulation results in differential gene expression, leading to cell specialization.
- A variety of intercellular and intracellular signal transmissions mediate gene expression.
- Changes in genotype can result in changes in phenotype.
- Biological systems have multiple processes that increase genetic variation
- Viral replication results in genetic variation and viral infection can introduce genetic variation into the hosts.
- Cell communication processes share common features that reflect a shared evolutionary history.
- Cells communicate with each other through direct contact with other cells or from a distance via chemical
- Signal transduction pathways link signal reception with cellular response.
- Changes in signal transduction pathways can alter cellular response.
- Individuals can act on information and communicate it to others.
- Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce response

Unit Essential Questions

- Why does heritable information provide for the continuity of life?
- Why does the expression of genetic information involve cellular and molecular mechanisms?
- Why is the processing of genetic information imperfect and a source of genetic variation?
- Why do cells communicate by generating, transmitting and receiving chemical signals?
- Why does the transmission of information result in changes within and between biological systems?

College Board Unit Standards

BIG IDEA:
Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.

LEARNING OBJECTIVES:
LO 3.1 The student is able to construct scientific explanations that use the structures and mechanisms of DNA and RNA to support the claim that DNA and, in some cases, RNA are the primary sources of heritable information. [See SP 6.2, 6.5]
LO 3.2 The student is able to justify the selection of data from historical investigations that support the claim that DNA is the source of heritable information. [See SP 4.1]
LO 3.3 The student is able to describe representations and models that illustrate how genetic information is copied for transmission between generations. [See SP 1.2]
LO 3.4 The student is able to describe representations and models illustrating how genetic information is translated into polypeptides. [See SP 1.2]
LO 3.5 The student can explain how heritable information can be manipulated using common technologies. [See SP 6.2, 6.4]
LO 3.6 The student can predict how a change in a specific DNA or RNA sequence can result in changes in gene expression. [See SP 6.4]
LO 3.7 The student can make predictions about natural phenomena occurring during the cell cycle. [See SP 6.2, 6.5]
LO 3.8 The student can describe the events that occur in the cell cycle. [See SP 1.2]
LO 3.9 The student is able to construct an explanation, using visual representations or narratives, as to how DNA in chromosomes is transmitted to the next generation via mitosis, or meiosis followed by fertilization. [See SP 6.2]
LO 3.10 The student is able to represent the connection between meiosis and increased genetic diversity necessary for evolution. [See SP 7.1]
LO 3.11 The student is able to evaluate evidence provided by data sets to support the claim that heritable information is passed from one generation to another generation through mitosis, or meiosis followed by fertilization. [See SP 5.3]
LO 3.12 The student is able to construct a representation that connects the process of meiosis to the passage of traits from parent to offspring. [See SP 1.1, 7.2]
LO 3.13 The student is able to pose questions about ethical, social or medical issues surrounding human genetic disorders. [See SP 3.1]
LO 3.14 The student is able to apply mathematical routines to determine Mendelian patterns of inheritance provided by data sets. [See SP 2.2]
LO 3.15 The student is able to explain deviations from Mendel’s model of the inheritance of traits. [See SP 6.2, 6.5]
LO 3.16 The student is able to explain how the inheritance patterns of many traits cannot be accounted for by Mendelian genetics. [See SP 6.3]
LO 3.17 The student is able to describe representations of an appropriate example of inheritance patterns that cannot be explained by Mendel’s model of the inheritance of traits. [See SP 1.2]
LO 3.18 The student is able to describe the connection between the regulation of gene expression and observed differences between different kinds of organisms. [See SP 7.1]
LO 3.19 The student is able to describe the connection between the regulation of gene expression and observed differences between individuals in a population. [See SP 7.1]
LO 3.20 The student is able to explain how the regulation of gene expression is essential for the processes and structures that support efficient cell function. [See SP 6.2]
LO 3.21 The student can use representations to describe how gene regulation influences cell products and function. [See SP 1.4]

LO 3.22 The student is able to explain how signal pathways mediate gene expression, including how this process can affect protein production. [See SP 6.2]
LO 3.23 The student can use representations to describe mechanisms of the regulation of gene expression. [See SP 1.4]
LO 3.24 The student is able to predict how a change in genotype, when expressed as a phenotype, provides a variation that can be subject to natural selection. [See SP 6.4, 7.2]
LO 3.25 The student can create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced. [See SP 1.1]
LO 3.26 The student is able to explain the connection between genetic variation in organisms and phenotypic variation in populations. [See SP 7.2]
LO 3.27 The student is able to compare and contrast processes by which genetic variation is produced and maintained in organisms from multiple domains. [See SP 7.2]
LO 3.28 The student is able to construct an explanation of the multiple processes that increase variation within a population. [See SP 6.2]
LO 3.29 The student is able to construct an explanation of how viruses introduce genetic variation in host organisms. [See SP 6.2]
LO 3.30 The student is able to use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population. [See SP 1.4]
LO 3.31 The student is able to describe basic chemical processes for cell communication shared across evolutionary lines of descent. [See SP 7.2]
LO 3.32 The student is able to generate scientific questions involving cell communication as it relates to the process of evolution. [See SP 3.1]
LO 3.33 The student is able to use representation(s) and appropriate models to describe features of a cell signaling pathway. [See SP 1.4]
LO 3.34 The student is able to construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling. [See SP 6.2]
LO 3.35 The student is able to create representation(s) that depict how cell-to-cell communication occurs by direct contact or from a distance through chemical signaling. [See SP 1.1]
LO 3.36 The student is able to describe a model that expresses the key elements of signal transduction pathways by which a signal is converted to a cellular response. [See SP 1.5]
LO 3.37 The student is able to justify claims based on scientific evidence that changes in signal transduction pathways can alter cellular response. [See SP 6.1]
LO 3.38 The student is able to describe a model that expresses key elements to show how change in signal transduction can alter cellular response. [See SP 1.5]
LO 3.39 The student is able to construct an explanation of how certain drugs affect signal reception and, consequently, signal transduction pathways. [See SP 6.2]
LO 3.40 The student is able to analyze data that indicate how organisms exchange information in response to internal changes and external cues, and which can change behavior. [See SP 5.1]
LO 3.41 The student is able to create a representation that describes how organisms exchange information in response to internal changes and external cues, and which can result in changes in behavior. [See SP 1.1]
LO 3.42 The student is able to describe how organisms exchange information in response to internal changes or environmental cues. [See SP 7.1]
LO 3.43 The student is able to construct an explanation, based on scientific theories and models, about how nervous systems detect external and internal signals, transmit and integrate information, and produce responses. [See SP 6.2, 7.1]

LO 3.44 The student is able to describe how nervous systems detect external and internal signals. [See SP 1.2]
LO 3.45 The student is able to describe how nervous systems transmit information. [See SP 1.2] LO 3.46 The student is able to describe how the vertebrate brain integrates information to produce a response. [See SP 1.2]
LO 3.47 The student is able to create a visual representation of complex nervous systems to describe/explain how these systems detect external and internal signals, transmit and integrate information, and produce responses. [See SP 1.1]
LO 3.48 The student is able to create a visual representation to describe how nervous systems detect external and internal signals. [See SP 1.1]
LO 3.49 The student is able to create a visual representation to describe how nervous systems transmit information. [See SP 1.1]
LO 3.50 The student is able to create a visual representation to describe how the vertebrate brain integrates information to produce a response. [See SP 1.1]

Unit 4: Biological systems interact, and these systems and their interactions possess complex properties

Overview

All biological systems are composed of parts that interact with each other from the molecular level to the ecosystem level and exhibit properties of biocomplexity and diversity. Variations in components within biological systems provide a greater flexibility to respond to changes in its environment.

Performance Expectations

At the conclusion of this unit, students will be able to evaluate why:

- The subcomponents of biological molecules and their sequence determine the properties of that molecule.
- The structure and function of subcellular components, and their interactions, provide essential cellular processes.
- Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.
- Organisms exhibit complex properties due to interactions between their constituent parts.
- Communities are composed of populations of organisms that interact in complex ways.
- Interactions among living systems and with their environment result in the movement of matter and energy.
- Interactions between molecules affect their structure and function.
- Cooperative interactions within organisms promote efficiency in the use of energy and matter.
- Interactions between and within populations influence patterns of species distribution and abundance.
- Distribution of local and global ecosystems changes over time.
- Variation in molecular units provides cells with a wider range of functions.
- Environmental factors influence the expression of the genotype in an organism.
- The level of variation in a population affects population dynamics.
- The diversity of species within an ecosystem may influence the stability of the ecosystem.

Unit Essential Questions

- Why do interactions within biological systems lead to complex properties?
- Why are competition and cooperation important aspects of biological systems?
- Why does naturally occurring diversity among and between components within biological systems affect interactions with the environment?

College Board Unit Standards

BIG IDEA:
Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

LEARNING OBJECTIVES:
LO 4.1 The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties. [See SP 7.1]
LO 4.2 The student is able to refine representations and models to explain how the subcomponents of a biological polymer and their sequence determine the properties of that polymer. [See SP 1.3]
LO 4.3 The student is able to use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule. [See SP 6.1, 6.4]
LO 4.4 The student is able to make a prediction about the interactions of subcellular organelles. [See SP 6.4]
LO 4.5 The student is able to construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions. [See SP 6.2]
LO 4.6 The student is able to use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions. [See SP 1.4]
LO 4.7 The student is able to refine representations to illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues and organs. [See SP 1.3]
LO 4.8 The student is able to evaluate scientific questions concerning organisms that exhibit complex properties due to the interaction of their constituent parts. [See SP 3.3]
LO 4.9 The student is able to predict the effects of a change in a component(s) of a biological system on the functionality of an organism(s). [See SP 6.4]
LO 4.10 The student is able to refine representations and models to illustrate biocomplexity due to interactions of the constituent parts. [See SP 1.3]
LO 4.11 The student is able to justify the selection of the kind of data needed to answer scientific questions about the interaction of populations within communities. [See SP 1.4, 4.1]
LO 4.12 The student is able to apply mathematical routines to quantities that describe communities composed of populations of organisms that interact in complex ways. [See SP 2.2]
LO 4.13 The student is able to predict the effects of a change in the community's populations on the community. [See SP 6.4]
LO 4.14 The student is able to apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy. [See SP 2.2]
LO 4.15 The student is able to use visual representations to analyze situations or solve problems qualitatively to illustrate how interactions among living systems and with their environment result in the movement of matter and energy. [See SP 1.4]
LO 4.16 The student is able to predict the effects of a change of matter or energy availability on communities.[See SP 6.4]
LO 4.17 The student is able to analyze data to identify how molecular interactions affect structure and function. [See SP 5.1]

LO 4.18 The student is able to use representations and models to analyze how cooperative interactions within organisms promote efficiency in the use of energy and matter. [See SP 1.4]
LO 4.19 The student is able to use data analysis to refine observations and measurements regarding the effect of population interactions on patterns of species distribution and abundance. [See SP 2.2, 5.2]
LO 4.20 The student is able to explain how the distribution of ecosystems changes over time by identifying large-scale events that have resulted in these changes in the past. [See SP 6.2, 6.3]
LO 4.21 The student is able to predict consequences of human actions on both local and global ecosystems. [See SP 6.4]
LO 4.22 The student is able to construct explanations based on evidence of how variation in molecular units provides cells with a wider range of functions. [See SP 6.2]
LO 4.23 The student is able to construct explanations of the influence of environmental factors on the phenotype of an organism. [See SP 6.2]
LO 4.24 The student is able to predict the effects of a change in an environmental factor on gene expression and the resulting phenotype of an organism. [See SP 6.4]
LO 4.25 The student is able to use evidence to justify a claim that a variety of phenotypic responses to a single environmental factor can result from different genotypes within the population. [See SP 6.1]
LO 4.26 The student is able to use theories and models to make scientific claims and/or predictions about the effects of variation within populations on survival and fitness. [See SP 6.4]
LO 4.27 The student is able to make scientific claims and predictions about how species diversity within an ecosystem influences ecosystem stability. [See SP 6.4]