AP Biology

The AP Biology course is designed to enable you to develop advanced inquiry and reasoning skills, such as designing a plan for collecting data, analyzing data, applying mathematical routines, and connecting concepts in and across domains. The result will be readiness for the study of advanced topics in subsequent college courses—a goal of every AP course.

This AP Biology course is equivalent to a two-semester college introductory biology course and has been endorsed enthusiastically by higher education officials.

Students must have completed both first year biology and chemistry prior to enrolling in the course. A summer assignment and three before school- class meetings in the first weeks of August, enables the students to review the basic principles of physical chemistry.

Science Inquiry and Application Standards

During the years of grades 9 through 12 all students must use the following scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas. These are ongoing skills that will be developed and intertwined within the content of each course.

- Identify questions and concepts that guide scientific investigations
- Design and conduct scientific investigations
- Use technology and mathematics to improve investigations and communications
- Formulate and revise explanations and models using logic and evidence (critical thinking)
- Recognize and analyze explanations and models
- Communicate and support a scientific argument

Oakwood City School District
AP Biology

English Language Arts Standards for Science & Technical Subjects

I Key Ideas and Details

- A Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- B Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- C Follow precisely a complex multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

II Craft and Structure

- A 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 11–12 texts and topics*.
- B Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
- C Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

III Integration of Knowledge and Ideas

- A Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- B Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
- C Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

IV Range of Reading and Level of Text Complexity

- A By the end of grade 12, read and comprehend science/technical texts in the grades 11–12 text complexity band independently and proficiently.

Content Standards

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

A Change in the genetic makeup of a population over time is evolution.

1 Natural selection is a major mechanism of evolution.

(a) According to Darwin's theory of natural selection, competition for limited resources results in differential survival. Individuals with more favorable phenotypes are more likely to survive and produce more offspring, thus passing traits to subsequent generations.

(b) Evolutionary fitness is measured by reproductive success.

(c) Genetic variation and mutation play roles in natural selection. A diverse gene pool is important for the survival of a species in a changing environment.

(d) Environments can be more or less stable or fluctuating, and this affects evolutionary rate and direction; different genetic variations can be selected in each generation.

(e) An adaptation is a genetic variation that is favored by selection and is manifested as a trait that provides an advantage to an organism in a particular environment.

(f) In addition to natural selection, chance and random events can influence the evolutionary process, especially for small populations.

(g) Conditions for a population or an allele to be in Hardy-Weinberg equilibrium are: (1) a large population size, (2) absence of migration, (3) no net mutations, (4) random mating and (5) absence of selection. These conditions are seldom met.

(h) Mathematical approaches are used to calculate changes in allele frequency, providing evidence for the occurrence of evolution in a population.

2 Natural selection acts on phenotypic variations in populations.

(a) Environments change and act as selective mechanism on populations.

(b) Phenotypic variations are not directed by the environment but occur through random changes in the DNA and through new gene combinations.

(c) Some phenotypic variations significantly increase or decrease fitness of the organism and the population.

(d) Humans impact variation in other species.

3 Evolutionary change is also driven by random processes.
(a) Genetic drift is a nonselective process occurring in small populations.
(b) Reduction of genetic variation within a given population can increase the differences between populations of the same species.

4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.
(a) Scientific evidence of biological evolution uses information from geographical, geological, physical, chemical and mathematical applications.
(b) Molecular, morphological and genetic information of existing and extinct organisms add to our understanding of evolution.

B Organisms are linked by lines of descent from common ancestry.
1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.
(a) Structural and functional evidence supports the relatedness of all domains.
(b) Structural evidence supports the relatedness of all eukaryotes.

2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.
(a) Phylogenetic trees and cladograms can represent traits that are either derived or lost due to evolution.
(b) Phylogenetic trees and cladograms illustrate speciation that has occurred, in that relatedness of any two groups on the tree is shown by how recently two groups had a common ancestor.
(c) Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species, and from DNA and protein sequence similarities, by employing computer programs that have sophisticated ways of measuring and representing relatedness among organisms.
(d) Phylogenetic trees and cladograms are dynamic (i.e., phylogenetic trees and cladograms are constantly being revised), based on the biological data used, new mathematical and computational ideas, and current and emerging knowledge.

C Life continues to evolve within a changing environment.
1 Speciation and extinction have occurred throughout the Earth's history.
(a) Speciation rates can vary, especially when adaptive radiation occurs when new habitats become available.
(b) Species extinction rates are rapid at times of ecological stress.

2 Speciation may occur when two populations become reproductively isolated from each other.
(a) Speciation results in diversity of life forms. Species can be physically separated by a geographic barrier such as an ocean or a mountain range, or various pre-and post-zygotic mechanisms can maintain reproductive isolation and prevent gene flow.
(b) New species arise from reproductive isolation over time, which can involve scales of hundreds of thousands or even millions of years, or speciation can occur rapidly through mechanisms such as polyploidy in plants.

3 Populations of organisms continue to evolve.
(a) Scientific evidence supports the idea that evolution has occurred in all species.
(b) Scientific evidence supports the idea that evolution continues to occur.

D The origin of living systems is explained by natural processes.
1 There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.
(a) Scientific evidence supports the various models.

2 Scientific evidence from many different disciplines supports models of the origin of life.
(a) Geological evidence provides support for models of the origin of life on Earth.
(b) Molecular and genetic evidence from extant and extinct organisms indicates that all organisms on Earth share a common ancestral origin of life.

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

A Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
1 All living systems require constant input of free energy.
(a) Life requires a highly ordered system.
(b) Living systems do not violate the second law of thermodynamics, which states that entropy increases over time.
(c) Energy-related pathways in biological systems are sequential and may be entered at multiple points in the pathway.
(d) Organisms use free energy to maintain organization, grow and reproduce.

(e) Changes in free energy availability can result in changes in population size.
(f) Changes in free energy availability can result in disruptions to an ecosystem.

2 Organisms capture and store free energy for use in biological processes.
(a) Autotrophs capture free energy from physical sources in the environment.
(b) Heterotrophs capture free energy present in carbon compounds produced by other organisms.
(c) Different energy-capturing processes use different types of electron acceptors.
(d) The light-dependent reactions of photosynthesis in eukaryotes involve a series of coordinated reaction pathways that capture free energy present in light to yield ATP and NADPH, which power the production of organic molecules.
(e) Photosynthesis first evolved in prokaryotic organisms; scientific evidence supports that prokaryotic (bacterial) photosynthesis was responsible for the production of an oxygenated atmosphere; prokaryotic photosynthetic pathways were the foundation of eukaryotic photosynthesis.
(f) Cellular respiration in eukaryotes involves a series of coordinated enzyme-catalyzed reactions that harvest free energy from simple carbohydrates.
(g) The electron transport chain captures free energy from electrons in a series of coupled reactions that establish an electrochemical gradient across membranes.
(h) Free energy becomes available for metabolism by the conversion of ATP→ADP, which is coupled to many steps in metabolic pathways.

3 Organisms must exchange matter with the environment to grow, reproduce and maintain organization.
(a) Molecules and atoms from the environment are necessary to build new molecules.
(b) Surface area-to-volume ratios affect a biological system's ability to obtain necessary resources or eliminate waste products.

B Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.
1 Cell membranes are selectively permeable due to their structure.
(a) Cell membranes separate the internal environment of the cell from the external environment.

(b) Selective permeability is a direct consequence of membrane structure, as described by the fluid mosaic model.
(c) Cell walls provide a structural boundary, as well as a permeability barrier for some substances to the internal environments.

2 Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.
(a) Passive transport does not require the input of metabolic energy; the net movement of molecules is from high concentration to low concentration.
(b) Active transport requires free energy to move molecules from regions of low concentration to regions of high concentration.
(c) The processes of endocytosis and exocytosis move large molecules from the external environment to the internal environment and vice versa, respectively.

3 Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.
(a) Internal membranes facilitate cellular processes by minimizing competing interactions and by increasing surface area where reactions can occur.
(b) Membranes and membrane-bound organelles in eukaryotic cells localize (compartmentalize) intracellular metabolic processes and specific enzymatic reactions.
(c) Archaea and Bacteria generally lack internal membranes and organelles and have a cell wall.

C Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.
1 Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.
(a) Negative feedback mechanisms maintain dynamic homeostasis for a particular condition (variable) by regulating physiological processes, returning the changing condition back to its target set point.
(b) Positive feedback mechanisms amplify responses and processes in biological organisms. The variable initiating the response is moved farther away from the initial set-point. Amplification occurs when the stimulus is further activated which, in turn, initiates an additional response that produces system change.
(c) Alteration in the mechanisms of feedback often results in deleterious consequences.

2 Organisms respond to changes in their external environments.

(a) Organisms respond to changes in their environment through behavioral and physiological mechanisms.

D Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.

1 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.
(a) Cell activities are affected by interactions with biotic and abiotic factors.
(b) Organism activities are affected by interactions with biotic and abiotic factors.
(c) The stability of populations, communities and ecosystems is affected by interactions with biotic and abiotic factors.

2 Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.
(a) Continuity of homeostatic mechanisms reflects common ancestry, while changes may occur in response to different environmental conditions.
(b) Organisms have various mechanisms for obtaining nutrients and eliminating wastes.
(c) Homeostatic control systems in species of microbes, plants and animals support common ancestry.

3 Biological systems are affected by disruptions to their dynamic homeostasis.
(a) Disruptions at the molecular and cellular levels affect the health of the organism.
(b) Disruptions to ecosystems impact the dynamic homeostasis or balance of the ecosystem.

4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.
(a) Plants, invertebrates and vertebrates have multiple, nonspecific immune responses.
(b) Mammals use specific immune responses triggered by natural or artificial agents that disrupt dynamic homeostasis.

E Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.

1 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.

(a) Observable cell differentiation results from the expression of genes for tissue-specific proteins.
(b) Induction of transcription factors during development results in sequential gene expression.
(c) Programmed cell death (apoptosis) plays a role in the normal development and differentiation.

2 Timing and coordination of physiological events are regulated by multiple mechanisms.
(a) In plants, physiological events involve interactions between environmental stimuli and internal molecular signals.
(b) In animals, internal and external signals regulate a variety of physiological responses that synchronize with environmental cycles and cues.
(c) In fungi, protists and bacteria, internal and external signals regulate a variety of physiological responses that synchronize with environmental cycles and cues.

3 Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.
(a) Individuals can act on information and communicate it to others.
(b) Responses to information and communication of information are vital to natural selection.

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

A Heritable information provides for continuity of life.
1 DNA, and in some cases RNA, is the primary source of heritable information.
(a) Genetic information is transmitted from one generation to the next through DNA or RNA.
(b) DNA and RNA molecules have structural similarities and differences that define function.
(c) Genetic information flows from a sequence of nucleotides in a gene to a sequence of amino acids in a protein.
(d) Phenotypes are determined through protein activities.
(e) Genetic engineering techniques can manipulate the heritable information of DNA and, in special cases, RNA.
(f) Illustrative examples of products of genetic engineering include: Genetically modified foods, Transgenic animals Cloned animals, Pharmaceuticals, such as human insulin or factor X.

2 In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.
   (a) The cell cycle is a complex set of stages that is highly regulated with checkpoints, which determine the ultimate fate of the cell.
   (b) Mitosis passes a complete genome from the parent cell to daughter cells.
   (c) Meiosis, a reduction division, followed by fertilization ensures genetic diversity in sexually reproducing organisms.

3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.
   (a) Rules of probability can be applied to analyze passage of single gene traits from parent to offspring.
   (b) Segregation and independent assortment of chromosomes result in genetic variation.
   (c) Certain human genetic disorders can be attributed to the inheritance of single gene traits or specific chromosomal changes, such as nondisjunction.
   (d) Many ethical, social and medical issues surround human genetic disorders.

4 The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.
   (a) Many traits are the product of multiple genes and/or physiological processes.
   (b) Some traits are determined by genes on sex chromosomes.
   (c) Some traits result from nonnuclear inheritance.

B Expression of genetic information involves cellular and molecular mechanisms.
   1 Gene regulation results in differential gene expression, leading to cell specialization.
      (a) Both DNA regulatory sequences, regulatory genes, and small regulatory RNAs are involved in gene expression.
      (b) Both positive and negative control mechanisms regulate gene expression in bacteria and viruses.
      (c) In eukaryotes, gene expression is complex and control involves regulatory genes, regulatory elements and transcription factors that act in concert.

   2 A variety of intercellular and intracellular signal transmissions mediate gene expression.

(a) Signal transmission within and between cells mediates gene expression.
(b) Signal transmission within and between cells mediates cell function.

C The processing of genetic information is imperfect and is a source of genetic variation.
1 Changes in genotype can result in changes in phenotype.
(a) Alterations in a DNA sequence can lead to changes in the type or amount of the protein produced and the consequent phenotype.
(b) Errors in DNA replication or DNA repair mechanisms, and external factors, including radiation and reactive chemicals, can cause random changes, e.g., mutations in the DNA.
(c) Errors in mitosis or meiosis can result in changes in phenotype.
(d) Changes in genotype may affect phenotypes that are subject to natural selection. Genetic changes that enhance survival and reproduction can be selected by environmental conditions.
2 Biological systems have multiple processes that increase genetic variation.
(a) The imperfect nature of DNA replication and repair increases variation.
(b) The horizontal acquisitions of genetic information primarily in prokaryotes via transformation (uptake of naked DNA), transduction (viral transmission of genetic information), conjugation (cell-to-cell transfer) and transposition (movement of DNA segments within and between DNA molecules) increase variation.
(c) Sexual reproduction in eukaryotes involving gamete formation, including crossing-over during meiosis and the random assortment of chromosomes during meiosis, and fertilization serve to increase variation. Reproduction processes that increase genetic variation are evolutionarily conserved and are shared by various organisms.

3 Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.
(a) Viral replication differs from other reproductive strategies and generates genetic variation via various mechanisms.
(b) The reproductive cycles of viruses facilitate transfer of genetic information.

D Cells communicate by generating, transmitting and receiving chemical signals.
1 Cell communication processes share common features that reflect a shared evolutionary history.
(a) Communication involves transduction of stimulatory or inhibitory signals from other cells, organisms or the environment.

(b) Correct and appropriate signal transduction processes are generally under strong selective pressure.
(c) In single-celled organisms, signal transduction pathways influence how the cell responds to its environment.
(d) In multicellular organisms, signal transduction pathways coordinate the activities within individual cells that support the function of the organism as a whole.

2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.
(a) Cells communicate by cell-to-cell contact.
(b) Cells communicate over short distances by using local regulators that target cells in the vicinity of the emitting cell.
(c) Signals released by one cell type can travel long distances to target cells of another cell type.

3 Signal transduction pathways link signal reception with cellular response.
(a) Signaling begins with the recognition of a chemical messenger, a ligand, by a receptor protein.
(b) Signal transduction is the process by which a signal is converted to a cellular response.

4 Changes in signal transduction pathways can alter cellular response.
(a) Conditions where signal transduction is blocked or defective can be deleterious, preventative or prophylactic.

E Transmission of information results in changes within and between biological systems.
1 Individuals can act on information and communicate it to others.
(a) Organisms exchange information with each other in response to internal changes and external cues, which can change behavior.
(b) Communication occurs through various mechanisms.
(c) Responses to information and communication of information are vital to natural selection and evolution.

2 Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.
(a) The neuron is the basic structure of the nervous system that reflects function.
(b) Action potentials propagate impulses along neurons.
(c) Transmission of information between neurons occurs across synapses.
(d) Different regions of the vertebrate brain have different functions.

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

A Interactions within biological systems lead to complex properties.

1 The subcomponents of biological molecules and their sequence determine the properties of that molecule.
   (a) Structure and function of polymers are derived from the way their monomers are assembled.
   (b) Directionality influences structure and function of the polymer.

2 The structure and function of subcellular components, and their interactions, provide essential cellular processes.
   (a) Ribosomes are small, universal structures comprised of two interacting parts: ribosomal RNA and protein. In a sequential manner, these cellular components interact to become the site of protein synthesis where the translation of the genetic instructions yields specific polypeptides.
   (b) Endoplasmic reticulum (ER) occurs in two forms: smooth and rough.
   (c) The Golgi complex is a membrane-bound structure that consists of a series of flattened membrane sacs
   (d) Mitochondria specialize in energy capture and transformation.
   (e) Lysosomes are membrane-enclosed sacs that contain hydrolytic enzymes, which are important in intracellular digestion, the recycling of a cell's organic materials and programmed cell death (apoptosis). Lysosomes carry out intracellular digestion in a variety of ways.
   (f) A vacuole is a membrane-bound sac that plays roles in intracellular digestion and the release of cellular waste products. In plants, a large vacuole serves many functions, from storage of pigments or poisonous substances to a role in cell growth. In addition, a large central vacuole allows for a large surface area to volume ratio.
   (g) Chloroplasts are specialized organelles found in algae and higher plants that capture energy through photosynthesis.

3 Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.
   (a) Differentiation in development is due to external and internal cues that trigger gene regulation by proteins that bind to DNA.
   (b) Structural and functional divergence of cells in development is due to expression of genes specific to a particular tissue or organ type.
   (c) Environmental stimuli can affect gene expression in a mature cell.

4 Organisms exhibit complex properties due to interactions between their constituent parts.

(a) Interactions and coordination between organs provide essential biological activities.
(b) Interactions and coordination between systems provide essential biological activities.

5 Communities are composed of populations of organisms that interact in complex ways.
(a) The structure of a community is measured and described in terms of species composition and species diversity.
(b) Mathematical or computer models are used to illustrate and investigate population interactions within and environmental impacts on a community.
(c) Mathematical models and graphical representations are used to illustrate population growth patterns and interactions.

6 Interactions among living systems and with their environment result in the movement of matter and energy.
(a) Energy flows, but matter is recycled.
(b) Changes in regional and global climates and in atmospheric composition influence patterns of primary productivity.
(c) Organisms within food webs and food chains interact.
(d) Food webs and food chains are dependent on primary productivity.
(e) Models allow the prediction of the impact of change in biotic and abiotic factors.
(f) Human activities impact ecosystems on local, regional and global scales.
(g) Many adaptations of organisms are related to obtaining and using energy and matter in a particular environment.

B Competition and cooperation are important aspects of biological systems.
1 Interactions between molecules affect their structure and function.
(a) Change in the structure of a molecular system may result in a change of the function of the system.
(b) The shape of enzymes, active sites and interaction with specific molecules are essential for basic functioning of the enzyme.
(c) Other molecules and the environment in which the enzyme acts can enhance or inhibit enzyme activity. Molecules can bind reversibly or irreversibly to the active or allosteric sites, changing the activity of the enzyme.
(d) The change in function of an enzyme can be interpreted from data regarding the concentrations of product or substrate as a function of time. These representations demonstrate the relationship between an enzyme's activity, the disappearance of substrate, and/or presence of a competitive inhibitor.

2 Cooperative interactions within organisms promote efficiency in the use of energy and matter.
(a) Organisms have areas or compartments that perform a subset of functions related to energy and matter, and these parts contribute to the whole.

3 Interactions between and within populations influence patterns of species distribution and abundance.
(a) Interactions between populations affect the distributions and abundance of populations.
(b) A population of organisms has properties that are different from those of the individuals that make up the population. The cooperation and competition between individuals contributes to these different properties.
(c) Species-specific and environmental catastrophes, geological events, the sudden influx/depletion of abiotic resources or increased human activities affect species distribution and abundance.

4 Distribution of local and global ecosystems changes over time.
(a) Human impact accelerates change at local and global levels.
(b) Geological and meteorological events impact ecosystem distribution.

C Geological and meteorological events impact ecosystem distribution.
1 Variation in molecular units provides cells with a wider range of functions.
(a) Variations within molecular classes provide cells and organisms with a wider range of functions.
(b) Multiple copies of alleles or genes (gene duplication) may provide new phenotypes.

2 Environmental factors influence the expression of the genotype in an organism.
(a) Environmental factors influence many traits both directly and indirectly.
(b) An organism's adaptation to the local environment reflects a flexible response of its genome.

3 The level of variation in a population affects population dynamics.
(a) Population ability to respond to changes in the environment is affected by genetic diversity. Species and populations with little genetic diversity are at risk for extinction.
(b) Genetic diversity allows individuals in a population to respond differently to the same changes in environmental conditions.

(c) Allelic variation within a population can be modeled by the Hardy-Weinberg equation(s).

4 The diversity of species within an ecosystem may influence the stability of the ecosystem.
(a) Natural and artificial ecosystems with fewer component parts and with little diversity among the parts are often less resilient to changes in the environment.
(b) Keystone species, producers, and essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem. The effects of keystone species on the ecosystem are disproportionate relative to their abundance in the ecosystem, and when they are removed from the ecosystem, the ecosystem often collapses.