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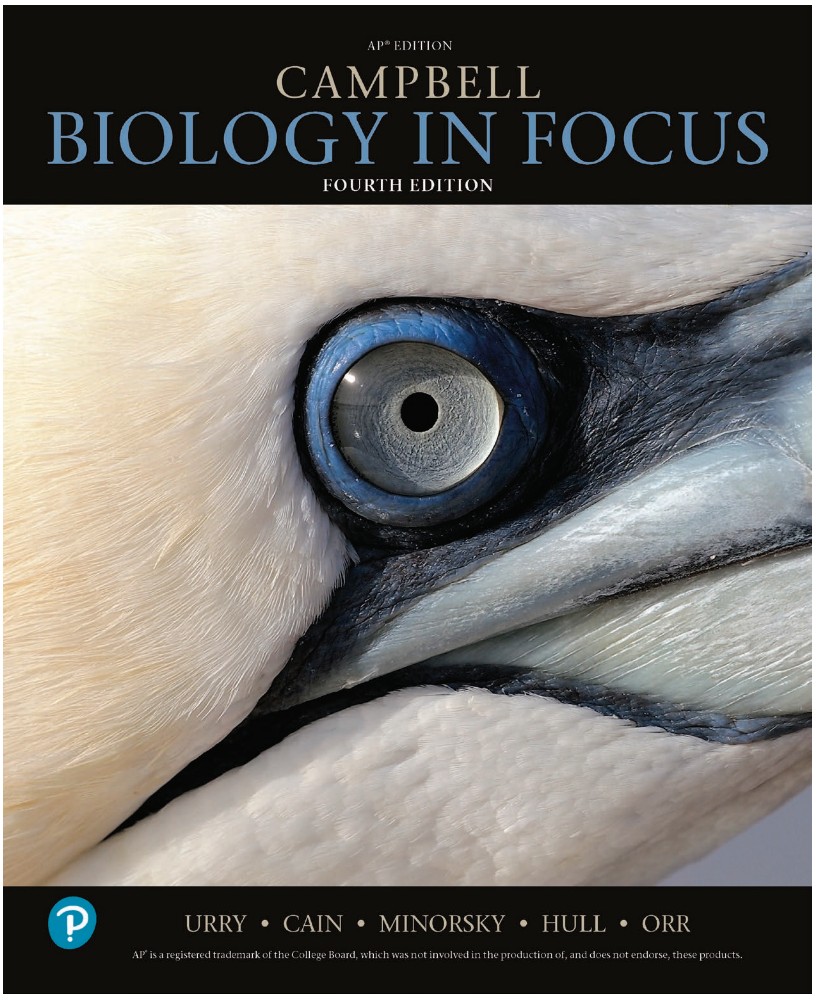

To the

AP® Biology Curriculum Framework
Effective Fall 2025

Pearson

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Big Idea Summary

Big Idea 1: Evolution (EVO)
The process of evolution drives the diversity and unity of life.
Evolution is a change in the genetic makeup of a population over time, with natural selection as its major driving mechanism. Darwin's theory, which is supported by evidence from many scientific disciplines, states that inheritable variations occur in individuals in a population. Due to competition for limited resources, individuals with more favorable genetic variations are more likely to survive and produce more offspring, thus passing traits to future generations. A diverse gene pool is vital for the survival of species because environmental conditions change. The process of evolution explains the diversity and unity of life, but an explanation about the origin of life is less clear.

In addition to the process of natural selection, naturally occurring catastrophic and human-induced events, as well as random environmental changes can result in alteration in the gene pools of populations. Scientific evidence supports that 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.

Big Idea 2: Energetics (ENE)
Biological systems use energy and molecular building blocks to grow, to reproduce, and maintain dynamic homeostasis.
Cells and organisms must exchange matter with the environment. Organisms respond to changes in their environment at the molecular, cellular, physiological, and behavioral levels. Living systems require energy and matter to maintain order, to grow, and to reproduce. Organisms employ various strategies to capture, use, and store energy and other vital resources. Energy deficiencies are not only detrimental to individual organisms; they also can cause disruptions at the population and ecosystem levels. Homeostatic mechanisms that are conserved or divergent across related organisms reflect either continuity due to common ancestry or evolutionary change in response to distinct selective pressures.

Big Idea 3: Information Storage and Transmission (IST)
Living systems store, retrieve, transmit, and respond to information essential to life processes. Genetic inf ormation provides for continuity of life and, in most cases, this information is passed from parent to offspring via DNA. Nonheritable information transmission influences behavior within and between cells, organisms, and populations. These behaviors are directed by underlying genetic information, and responses to information are vital to natural selection and evolution. Genetic information is a repository of instructions necessary for the survival, growth, and reproduction of the organism.
Genetic variation can be advantageous for the long-term survival and evolution of a species.

Big Idea 4: Systems Interactions (SYI)
Biological systems interact, and these systems and their interactions exhibit complex properties. All biological systems comprise parts that interact with one another. These interactions result in characteristics and emergent properties not found in the individual parts alone. All biological systems from the molecular level to the ecosystem level exhibit properties of biocomplexity and diversity. These two properties provide robustness to biological systems, enabling greater resiliency and flexibility to tolerate and respond to changes in the environment.

AP® Biology Topics	Big Ideas	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4th Edition
Unit 1: Chemistry of Life (7 Topics)				
1.1 Structure of Water and Hydrogen Bonding	**Big Idea 4** Systems Interactions	**1.1A:** Explain how the properties of water that result from its polarity and hydrogen bonding affect its biological functions	**1.1.A.1:** Living systems depend on the properties of water to sustain life. i. Water had polarity, because of the formation of polar covalent bonds between hydrogen and oxygen within water molecules. This polarity contributes to hydrogen bonding between and within biological molecules. ii. Water has a high specific heat capacity, which allows for the maintenance of homeostatic body temperature within living organisms. iii. Water has a high heat of vaporization, which allows for the evaporative cooling of the surrounding environment. In living organisms, this property allows for body temperature to be maintained.	Figure 2.1: How does water's chemical structure allow its solid form (ice) to float on liquid water? Concept 2.3: The formation and function of molecules depend on chemical bonding between atoms
			1.1.A.2: The hydrogen bonds between adjacent polar water molecules result in cohesion, adhesion, and surface tension.	Concept 2.5: Hydrogen bonding gives water properties that help make life possible on Earth
1.2 Elements of Life	**Big Idea 2** Energetics	**1.2.A:** Describe the composition of macromolecules required by living organisms.	**1.2.A.1:** Atoms and molecules from the environment are necessary to build new molecules. Carbon, hydrogen, and oxygen are the most prevalent elements used to build biological molecules such as carbohydrates, proteins, lipids, and nucleic acids. Additionally i. Sulfur is used in the building of proteins. ii. Phosphorus is used in the building of phospholipids (a type of lipid) and nucleic acids. iii. Nitrogen is used in the building of nucleic acids.	Concept 3.1: Carbon atoms can form diverse molecules by bonding to four other atoms
1.3 Introduction to Macromolecules	**Big Idea 4** Systems Interactions	**1.3.A:** Describe the chemical reactions that build and break biological macromolecules.	**1.3.A.1:** Hydrolysis is a chemical reaction involving the cleaving of covalent bonds. This type of reaction breaks down molecules iinto smaller molecules. When water is added to the bond between monomers in a polymer, the bond is broken. The hydrogen ion from a water molecule is added to one monomer and the hydroxyl	Concept 3.2: Macromolecules are polymers, built from monomers

			group of the water molecule is added to the other monomer completing the reaction. 1.3.A.2 Dehydration synthesis occurs when two smaller molecules are joined together through covalent bonding. A hydrogen ion is removed from one monomer and a hydroxyl group is removed from the other. This causes the loss of the equivalent of a water molecule from the reactants and the connection of the two remaining monomers. The connection of many monomers is known as polymerization.	
1.4 Carbohydrates	**Big Idea 4** Systems Interactions	**1.4.A:** Describe the structure and function of carbohydrates.	**1.4.A.1:** Monosaccharides (simple sugars) are the monomers for poly saccharides (complex carbohydrates). These monomers are connected by covalent bonds to form polymers such as complex carbohydrates, which may be linear or branched.	Concept 3.3: Carbohydrates serve as fuel and building material
1.5 Lipids	**Big Idea 4** Systems Interactions	**1.5.A:** Describe the structure and function of lipids.	**1.5.A.1:** Lipids are typically nonpolar, hydrophobic molecules whose structure and function are derived from the way their subcomponents are assembled. i. Fatty acids contain only single bonds between carbon atoms. ii. Unsaturated fatty acids contain at least one double bond between carbon atoms, which causes the carbon chain to kink. iii. The more double bonds in a fatty acid tail, the more unsaturated the lipid becomes. iv. The more unsaturated a. lipid is, the more liquid it is at room temperature. 1.5.A.2 Lipids provide a variety of functions for living organisms. Some examples of lipids are fats, steroids including cholesterol, and phospholipids. i. Fats provide energy storage and support cell function. In some cases, they can also provide insulation to help keep mammals warm. ii. Steroids are hormones that support physiological functions including growth and development, energy metabolism, and homeostasis.	Concept 3.4: Lipids are a diverse group of hydrophobic molecules.

			iii. Cholesterol provides essential structural stability to animal cell membranes. iv. Phospholipids group together to form the lipid bilayers found in plasma and cell membranes.	
1.6 Nucleic Acids	**Big Idea 3** Information Storage and Transmission	**1.6A:** Describe the structure and function of DNA and RNA.	**1.6.A.1:** In nucleic acids (DNA and RNA) biological information is encoded in sequences of nucleotide monomers. Each nucleotide has the following structural components: a five-carbon sugar (deoxyribose or ribose), a phosphate, and a nitrogenous base (adenine, thymine, guanine, cytosine, or uracil). **1.6.A.2:** Nucleic acids have a linear sequence of nucleotides that have ends, defined by the 3' (three prime) hydroxyl and a 5' (five prime) phosphates of the sugar in the nucleotide. During nucleic acid synthesis, nucleotides are added to the 3' end of the growing strand, resulting in the formation of covalent bonds between nucleotides. **1.6.A.3:** DNA is structured as an antiparallel double helix, with two strands of nucleotides running in opposite 5' to 3' orientation. In DNA, adenine nucleotides pair with thymine nucleotides via hydrogen bonds (A-T), and cytosine nucleotides pair with guanine nucleotides via hydrogen bonds (C-G). In RNA, adenine pairs with uracil (A-U). 1.6.A.4 Structural differences between DNA and RNA include: i. DNA contains the sugar deoxyribose, and RNA contains the sugar ribose. ii. DNA contains the nitrogenous base thymine, and RNA contains the nitrogenous base uracil. iii. DNA is typically double stranded, while RNA is typically single stranded.	Concept 3.6: Nucleic acids store, transmit, and help express hereditary information. Concept 13.1: DNA is the genetic material Figure 13.7 Visualizing DNA
			1.7.A.1: Proteins comprise	.

1.7 Proteins	**Big Idea 4** Systems Interactions	**1.7.A:** Describe the structure and function of proteins.	linear chains of amino acids connected by the formation of covalent (peptide) bonds that form between a carboxyl group (-COOH) of one amino acid and an amine group (-NH_2) of the next amino acid, resulting in a growing peptide chain. **1.7.A.2:** Amino acids are composed of a central carbon atom with a hydrogen atom, a carboxyl group an amine group, and a variable R group covalently bound to it. The R group of an amino acid can be categorized by three possible chemical properties: hydrophobic/nonpolar, hydrophilic/polar, or ionic. The interactions of these R groups determine the structure and function of that region of the protein. **1.7.A.3:** The specific sequence of amino acids in proteins determines the primary structure of a polypeptide as well as the overall shape of the protein. **1.7.A.4:** Secondary structures of proteins are made through the local folding that forms from interactions between atoms of the polypeptide backbone of the amino acid chain. Hydrogen bonding forms shapes such as alpha-helices and beta-pleated sheets. **1.7.A.5:** The three-dimensional shape of the tertiary structure of a protein results from the formation of hydrogen bonds, hydrophobic interactions, ionic interactions, or disulfide bridges. **1.7.A.6:** The quaternary structure arises from interactions between multiple polypeptides. All four levels of a protein structure determine the function of a protein.	Concept 3.5: Proteins include a diversity of structures, resulting in a wide range of functions

AP® Biology Topics	Big Ideas:	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4th Edition
Unit 2: Cell Structure and Function (10 topics)				
2.1 Cell Structure and Function	**Big Idea 4** Systems Interactions	**2.1.A:** Explain how the structure and function of subcellular components and organelles contribute to the function of cells.	**2.1.A.1:** Ribosomes are comprised of ribosomal RNA (rRNA) and protein. These non-membrane, subcellular structures are found in cells in all forms of life and reflect the common ancestry in all known life. Ribosomes synthesize proteins according to messenger RNA (mRNA) sequences. **2.1.A.2:** The endomembrane system consists of a group of membrane-bound organelles and subcellular components (endoplasmic reticulum (ER), Golgi complex, lysosomes, vacuoles and transport vesicles, the nuclear envelope, and the plasma membrane) that work together to modify, package, and transport polysaccharides, lipids, and proteins intercellularly. **2.1.A.3:** Endoplasmic reticulum provides mechanical support by helping cells maintain shape and plays a role in intracellular transport. i. Rough ER is associated with membrane- bound ribosomes, allows for the compartmentalization of cells, and helps carry out protein synthesis. ii. Smooth ER functions include the detoxification of cells and lipid synthesis. **2.1.A.4:** The Golgi complex is a membrane-bound structure that consists of a series of flattened membrane sacs. Functions of the	Figure 4.1: How does the internal organization of eukaryotic cells allow them to perform the function of life? Concept 4.3: The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes Concept 4.4: The endomembrane system regulates protein traffic and performs metabolic functions Concept 4.5: Mitochondria and chloroplasts change energy from one form to another

			Golgi include: i. Correctly folding and chemically modifying newly synthesized cellular products ii. Packaging proteins for trafficking **2.1.A.5:** Mitochondria have a double membrane that provides compartments for different metabolic reactions involved in aerobic cellular respiration. The outer membrane is smooth, while the inner membrane is highly convoluted, forming folds that enable ATP to be synthesized more efficiently. **2.1.A.6:** Lysosomes are membrane-enclosed sacs that contain hydrolytic enzymes that digest material. Lysosomes also play a role in programmed cell death (apoptosis). **2.1.A.7:** Vacuoles are membrane-bound sacs that play many different roles. i. In plant cells, a specialized large vacuole maintains turgor pressure through nutrient and water storage. ii. In animal cells, vacuoles are smaller in size, are more plentiful than in plant cells, and store cellular materials. **2.1.A.8:** Chloroplasts are specialized organelles that are found in plants and photosynthetic algae. Chloroplasts contain a double membrane and serve as the location for photosynthesis.	Concept 4.4: The endomembrane system regulates protein traffic and performs metabolic functions Concept 4.5: Mitochondria and chloroplasts change energy from one form to another
2.2 Cell Size	**Big Idea 2** Energetics	**2.2A:** Explain the effect of surface area-to-volume rations on the	**2.2.A.1:** Surface area-to-volume ratios affect the ability of a biological system to obtain necessary nutrients, eliminate waste products, acquire or dissipate thermal energy, and otherwise exchange chemicals and energy with the	Concept 4.2: Eukaryotic cells have internal membranes that compartmentalize their functions.

		exchange of materials between cells or organisms and the environment.	environment. **RELEVANT EQUATIONS** Volume of a Sphere: $V = \frac{4}{3} r$ Volume of a Cube: $V = s^3$ Volume of a Rectangular Solid: $V = lwh$ Volume of a Cylinder: $V = r^2 h$ Surface Area of a Sphere: $SA = 4 r^2$ Surface Area of a Cube: $SA = 6s^2$ Surface Area of a Rectangular Solid: $SA = 2lh + 2lw + 2wh$ Surface Area of a Cylinder: $SA = 2 rh + 2 r^2$ r = radius l = length h = height w = width s=length of one side of a cube	Figure 4.6: Geometric relationships between surface area and volume. Scientific Skills Exercise: Using a Scale Bar to Calculate Volume and Surface Area of a Cell Concept 4.8: A cell is greater than the sum of its parts.
			2.2.A.2: The surface area of the plasma membrane must be large enough to adequately exchange materials. i. The surface area-to-volume ratio can restrict cell size and shape. Smaller cells typically have a higher surface area-to-volume ratio as well as a more efficient exchange of materials with the environment than do larger cells. ii. As cells increase in volume, the surface area-to-volume ratio decreases and the demand for internal resources increases. iii. More complex cellular structures (e.g., membrane folds) are necessary to adequately exchange materials with the environment. iv. As organisms increase in size, their surface area-to-	Appendix C: The Metric System Figure 26.14: Maximizing surface area

			volume ratio decreases, affecting properties like rate of heat exchange with the environment. Smaller amounts of mass exchange proportionally more heat with the ambient environment than do larger masses. As mass increases, both the surface area- to-volume ratio and the rate of heat exchange decrease. v. There is a relationship between metabolic rate per unit body mass and the size of multicellular organisms; typically, the smaller the organism, the higher the metabolic rate per unit body mass.	Concept 33.5: Feedback circuits regulate digestion, energy allocation and apppetite
2.3 Plasma Membranes	**Big Idea 2** Energetics	**2.3.A:** Describe the roles of each of the components of the cell membrane in maintaining the internal environment of the cell. **2.3.B:** Describe the fluid mosaic model of cell membranes.	**2.3.A.1:** Phospholipids have both hydrophilic and hydrophobic regions. The polar hydrophilic phosphate regions of the phospholipids are oriented toward the aqueous external or internal environment, while the nonpolar hydrophobic fatty acid regions face each other within the interior of the membrane. **2.3.A.2:** Embedded proteins can be hydrophilic (with charged and polar side groups), hydrophobic (with nonpolar side groups), or both. i. Hydrophilic regions of the proteins are either inside the interior of the protein or exposed to the cytosol (cytoplasm). ii. Hydrophobic regions of proteins make up the protein surface that interacts with the fatty acids in the interior membrane. **2.3.B.1:** Plasma membranes consist of a structural framework of phospholipid molecules embedded with proteins, steroids (such as cholesterol in vertebrate	Concept 4.2: Eukaryotic cells have internal membranes that compartmentalize their functions Concept 5.1: Cellular membranes are fluid mosaics of lipids and proteins

			animals), glycoproteins, and glycolipids. All of these can move around the surface of the cell within the membrane, as illustrated by the fluid mosaic model.	
2.4 Membrane Permeability	**Big Idea 2** Energetics	**2.4.A:** Explain how the structure of biological membranes influence selective permeability. **2.4.B:** Describe the role of the cell wall in mainlining cell structure and function.	**2.4.A.1:** Plasma membranes separate the internal environment of the cell from the external environment. Selective permeability is the result of the plasma membrane having a hydrophobic interior. **2.4.A.2:** Small nonpolar molecules including N_2, O_2, and CO_2, free pass across the membrane. Hydrophilic substances, such as large polar molecules and ions, move across the membrane through embedded channels and transport proteins. **2.4.A.3:** The nonpolar hydrocarbon tails of phospholipids prevent the movement of ions and polar molecules across the membrane. Small polar, uncharged molecules, like H_20, or NH_3 (ammonia), pass through the membrane in small amounts. **2.4.B.1:** Cell walls of Bacteria, Archaea, Fungi and plants provide a structural boundary as well las a permeability barrier for some substances to the internal or external cellular environments and protection from osmotic lysis.	Concept 5.2: Membrane structure results in selective permeability Figure 5.1: How does the plasma membrane regulate interactions between the cell and its environment? Concept 4.7: Extracellular components and connections between cells help coordinate cellular activities

AP® Biology Topics	Big Idea	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4th Edition
2.5 Membrane Transport	**Big Idea 2** Energetics	**2.5.A:** Describe the mechanisms that organisms use to maintain solute and water balance. 2.5.B: Describe the mechanisms that organisms use to transport large molecules across the plasma membrane.	**2.5.A.1:** The selective permeability of membranes allows for the formation of concentration gradients of solutes across the membrane. **2.5.A.2:** Passive transport is the net movement of molecules from regions of high concentration to regions of low concentration without the direct input of metabolic energy. **2.5.A.3:** Active transport requires the direct input of energy to move molecules. In some cases, active transport is utilized to move molecules from regions of low concentration to regions of high concentration. **2.5.B.1:** The processes of endocytosis and exocytosis require energy to move large substances or large amounts of substances into and out of cells. i. In endocytosis, the cell takes in large molecules and particulate matter by folding the plasma membrane in on itself and forming new (small) vesicles that engulf material from the external environment. ii. In exocytosis, internal vesicles release material from cells by fusing with the plasma membrane and secreting large molecules from the cell.	Concept 5.3: Passive transport is diffusion of a substance across a membrane with no energy investment. Concept 5.4: Active transport uses energy to move solutes against their gradients. Concept 5.5: Bulk transport across the plasma membrane occurs by exocytosis and endocytosis
2.6 Facilitated Diffusion	**Big Idea 2** Energetics	**2.6.A:** Explain how the structure of a molecule affects its ability to pass through the plasma membrane.	**2.6.A.1:** Facilitated diffusion requires transport or channel proteins to enable the movement of charged ions across the membrane. i. Membranes may become polarized by the movement of ions across the membrane. ii. Charged ions, including NA^+ (sodium) and K^+ (potassium) require channel proteins to move through the membrane. **2.6.A.2:** Facilitated diffusion enables the movement of large polar molecules through membranes with no energy input. In this type of	Concept 5.3: Passive transport is diffusion of a substance across a membrane with no energy investment.

			diffusion, substances move down the concentration gradient. **2.6.A.3:** Aquaporins transport large quantities of water across membranes.	
2.7 Tonicity and Osmoregulation	**Big Idea 2** Energetics	**2.7.A:** Explain how concentration gradients affect the movement of molecules across membranes.	**2.7.A.1:** External environments can be hypotonic, hypertonic, or isotonic to internal envi Movement of water can also be described as moving from hypotonic to hypertonic region osmosis from regions of high water potential to regions of low water potential. **RELEVANT EQUATION** Water Potential: *ps* where: *p* = pressure potential *s* = solute potential **2.7.B.1:** Growth and homeostasis are maintained by the constant movement of molecules across membranes.	Concept 5.3: Passive transport is diffusion of a substance across a membrane with no energy investment.
		2.7.B: Explain how osmoregulatory mechanisms contribute to the health and survival of organisms.	**2.7.B.2:** Osmoregulation maintains water balance and allows organisms to control their internal solute composition and water potential. Water moves from regions of low osmolarity or solute concentration to regions of high osmolarity or solute concentration. **RELEVANT EQUATION** Solute Potential of a Solution: $_s = -iCRT$ where: i = ionization constant C = molar concentration R = pressure constant $R = 0.0831 \frac{L\ bars}{mol\ K}$ T = temperature in Kelvin (°C + 273)	Concept 29.5: Transpiration drives the transport of water and minerals from roots to shoots via the xylem

2.8 Mechanisms of Transport	**Big Idea 2** Energetics	**2.8.A:** Describe the processes that allow ions and other molecules to move across membranes.	**2.8.A.1:** Metabolic energy (such as that from ATP) is required for active transport of molecules and ions across the membrane and to establish and maintain electrochemical gradients i. Membrane proteins are necessary for active transport. ii. the Na^+/K^+ pump and ATPase contribute to the maintenance of the membrane potential.	Concept 5.4: Active transport uses energy to move solutes against their gradients

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2.9 Cell Compartmentalization	**Big Idea 2** Energetics	**2.9.A:** Describe the membrane-bound structures of the eukaryotic cell. **2.9.B:** Explain how internal membranes and membrane-bound organelles contribute to compartmentalization of eukaryotic cell functions.	**2.9.A.1** Membranes and membrane-bound organelles in eukaryotic cells compartmentalize intracellular metabolic processes and specific enzymatic reactions. **2.9.B.1:** Internal membranes facilitate cellular processes by minimizing competing interactions and my increasing surface areas where reactions can occur.	Concept 4.2: Eukaryotic cells have internal membranes that compartmentalize their functions Concept 4.4: The endomembrane system regulates protein traffic and performs metabolic functions Concept 4.5: Mitochondria and chloroplasts change energy from one form to another
2.10 Origins of Cell Compartmentalization	**Big Idea 1** Evolution	**2.10.A:** Describe similarities and/or differences in compartmentalization between prokaryotic and eukaryotic cells.	**2.10.A.1:** Membrane-bound organelles such as mitochondria and chloroplasts evolved from once free-living prokaryotic cells via endosymbiosis. **2.10.A.2:** Prokaryotes typically lack internal membrane-bound organelles but have internal regions with specialized structures and functions. **2.10.A.3:** Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.	Figure 25.1: What ga e rise to the great diversity of eukaryotes, and how have eukaryotic lineages diverged over time? Concept 25.1: Eukaryotes arose by endosymbiosis more than 1.8 billion years ago Concept 24.2: Diverse structural and metabolic adaptations have evolved in prokaryotes Concept 4.2: Eukaryotic cells have internal membranes that compartmentalize their functions
Unit 3: Cellular Energetics (5 Topics)				
3.1 Enzymes	**Big Idea 2** Energetics	**3.1.A:** Explain how enzymes affect the rate of biological reactions.	**3.1.A.1:** The structure and function of enzymes contribute to the regulation of biological processes. Enzymes are proteins that are biological catalysts that facilitate chemical reactions in cells by lowering	Concept 3.5: Proteins include a diversity of structures resulting in a wide range of functions Concept 6.1: An organism's metabolism transforms matter and energy Concept 6.4: Enzymes speed up metabolic reactions by lowering energy barriers

			the activation energy **3.1.A.2:** For an enzyme-mediated chemical reaction to occur, the share and charge of the substrate must be compatible with the active site of the enzyme. This is illustrated by the enzyme-substrate complex model.	
3.2 Environmental Impacts on Enzyme Function	**Big Idea 2** Energetics	**3.2.A:** Explain how changes to the structure of an enzyme may affect its function. 3.2.B: Explain how the cellular environment affects enzyme activity.	**3.2.A.1:** Change to the molecular structure of a component in an enzymatic system may result in a change to its function or efficiency. i.Denaturation of proteins, such as enzymes, occurs when the protein structure is disrupted by a change in temperature, pH, or chemical environment, eliminating the ability to catalyze reactions. ii.Environmental temperatures and pH outside the optimal range for a given enzyme will cause changes to its structure (by disrupting the hydrogen bonds), altering the efficiency with which it catalyzes reactions. **3.2.A.2**: In some cases, enzyme denaturation is reversible, allowing the enzyme to regain activity. **3.2.B.1:** The relative concentrations of substrates and products determine how efficiently an enzymatic reaction proceeds. **3.2.B.2:** Higher	Concept 6.1: An organism's metabolism transforms matter and energy Concept 6.4: Enzymes speed up metabolic reactions by lowering energy barriers Concept 3.5: Proteins include a diversity of structures, resulting in a wide range of functions Concept 6.5: Regulation of enzyme activity helps control metabolism

			environmental temperatures increase the average speed of movement of molecules in a solution, increasing the frequency of collisions between enzyes and substrates and therefore increasing the rate of reaction until the optimal temperature is achieved. **3.2.B.3:** Competitive inhibitor molecules can bind reversibly to the active site of the enzyme. Noncompetitive inhibitors can bind to allosteric sites, changing the activity of the enzyme.	

AP® Biology Topics	Big Ideas	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4th Edition
3.3 Cellular Energy	**Big Idea 2** Energetics	**3.3.A:** Describe the role of energy in living organisms. **3.3.B:** Explain how shared, conserved, and fundamental processes and features support the concept of common ancestry for all organisms.	**3.3.A.1:** All living systems require an input of energy. **3.3.A.2:** Life requires a highly ordered system and does not violate the first and second laws of thermodynamics. i. Energy input must exceed energy loss to maintain order and to power cellular processes. ii.Cellular processes that release energy may be coupled with cellular processes that require energy. iii. Significant loss of order or energy flow results in death. 3**.3.A.3:** Energy-related pathways in biological systems are sequential to allow for a more controlled transfer of energy. A product of a reaction in a metabolic pathway is typically the reactant for the subsequent step in the pathway. **3.3.B.1:** Core metabolic pathways (e.g., glycolysis, oxidative phosphorylation) are conserved across all currently recognized domains (Archaea, Bacteria, and Eukarya).	Concept 6.1: An organism's metabolism transforms matter and energy Concept 6.2: The free-energy change of a reaction tells us whether or not the reaction occurs spontaneously. Figure 7.1: How is the chemical energy stored in food used to generate ATP, the molecule that drives most cellular work? Concept 6.3: ATP powers cellular work by coupling exergonic reactions to endergonic reactions. Concept 7.1: Catabolic pathways yield energy by oxidizing organic fuels Concept 7.5: Fermentation and anaerobic respiration enable cells to produce ATP without the use of oxygen
3.4 Photosynthesis	**Big Idea 2** Energetics	**3.4.A:** Describe the photosynthetic processes and structural features of the chloroplast that allow organisms to capture and store energy.	**3.4.A.1:** Photosynthesis is the series of reactions that use carbon dioxide (CO_2), water (H_2O), and light energy to make carbohydrates and oxygen (O_2). i. Photosynthetic organisms capture energy from the sun and produce sugars that can be used in biological processes or stored. ii. Photosynthesis first evolved in prokaryotic organisms.	Concept 8.1: Photosynthesis feeds the biosphere Concept 8.2: Photosynthesis converts light energy to the chemical energy of food Concept 24.1: Conditions on early Earth made the

			iii. Scientific evidence supports the claim that prokaryotic (cyanobacterial) photosynthesis was responsible for the production of an oxygenated atmosphere. iv. Prokaryotic photosynthetic pathways were the foundation of eukaryotic photosynthesis.	origin of life possible Concept 24.2: Diverse structural and metabolic adaptations have evolved in prokaryotes
			3.4.A.2: Stroma and thylakoids are found within the chloroplast. i. The stroma is the fluid within the inner chloroplast membrane and outside the thylakoid. The carbon fixation (Calvin cycle) reactions of photosynthesis occur in the stroma. ii. The thylakoid membranes contain chlorophyll pigments organized into two photosystems, as well as electron transport proteins. iii. Thylakoids are organized in stacks called grana. The light reactions of photosynthesis occur in the grana.	Concept 8.3: The light reactions convert solar energy to the Chemical energy of ATP and NADPH
			3.4.A.3: The light reactions of photosynthesis in eukaryotes involve a series of coordinated reaction pathways that capture energy present in light to yield ATP and NADPH, which power the production of organic molecules in the Calvin cycle. This provides energy for metabolic processes.	
		3.4.B: Explain how cells capture energy from light and transfer it to biological molecules for storage and use.	**3.4.B.1:** Electron transport chain (ETC) reactions occur in chloroplasts, in mitochondria, and across prokaryotic plasma membranes. In photosynthesis, electrons that pass through the thylakoid membrane are picked up and ultimately transferred to $NADP^+$ reducing it to NADPH in photosystem I. **3.4.B.2:** During photosynthesis, chlorophylls absorb energy from light, boosting electrons to a higher energy level in photosystems I and II. Water then splits, supplying electrons to replace those lost from photosystem II. **3.4.B.3:** Photosystems I and II are embedded in the thylakoid membranes of chloroplasts and are connected by the transfer of electrons through an ETC. **3.4.B.4:** When electrons are transferred between	figure 8.21: The working cell

			molecules in a series of oxidation/reduction reactions as they pass through the ETC, an electrochemical gradient of protons (hydrogen ions) is established across the thylakoid membrane. The membrane separates a region of low proton concentration outside the thylakoid membrane from a region of high proton concentration inside the thylakoid membrane. **3.4.B.5:** The formation of the proton gradient is linked to the synthesis of ATP from ADP and inorganic phosphate via ATP synthase. The flow of protons back through membrane-bound ATP synthase by chemiosmosis drives the formation of ATP from ADP and inorganic phosphate; this is known as photophosphorylation. **3.4.B.6:** The energy captured in the light reactions and transferred to ATP and NADPH powers the production of carbohydrates from carbon dioxide in the Calvin cycle. This occurs in the stroma of the chloroplast.	Concept 8.4: The Calvin cycle uses the chemical energy of ATP and NADPH to reduce CO_2 to sugar

3.5 Cellular Respiration	**Big Idea 2** Energetics	**3.5.A:** Describe he processes and structural features of mitochondria that allow organisms to use energy stored in biological macromolecules.	**3.5.A.1:** Cellular respiration uses energy from biological macromolecules to synthesize ATP. Respiration and fermentation are characteristic of all forms of life. **3.5.A.2:** Aerobic cellular respiration in eukaryotes involves a series of coordinated enzyme- catalyzed reactions that capture energy from biological macromolecules. **3.5.A.3:** The ETC transfers electrons in a series of oxidation-reduction reactions that establish an electrochemical gradient across membranes. i. In cellular respiration, electrons delivered by NADH and $FADH_2$ are passed to a series of electron acceptors as they move toward the terminal electron acceptor, oxygen. Aerobic prokaryotes use oxygen as a terminal electron acceptor, while anaerobic prokaryotes use other molecules. ii. The transfer of electrons, through the ETC, is accompanied by the formation of a proton gradient across the inner mitochondrial membrane, with the membrane(s) separating a region of high proton concentration outside the membrane from a region of low proton concentration inside the membrane. The folding of the inner membrane increases the surface area, which allows for more ATP to be synthesized. In prokaryotes, the passage of electrons is accompanied by the movement of protons across the plasma membrane. iii. The flow of protons back through membrane-bound ATP synthase by chemiosmosis drives the formation of ATP from ADP and inorganic phosphate. This is known as oxidative phosphorylation in aerobic cellular respiration. iv. In aerobic cellular respiration, decoupling oxidative phosphorylation from electron transport generates heat. This heat can be used by endothermic organisms to regulate body temperature. **3.5.B.1:** Glycolysis is a biochemical pathway that releases the energy in glucose molecules to form ATP (from ADP and inorganic	Concept 7.1: Catabolic pathways yield energy by oxidizing organic fuels Concept 7.4: During oxidative phosphorylation, chemiosmosis couples electron transport to ATP synthesis

		3.5.B: Explain how cells obtain energy from biological macromolecules in order to power cellular functions.	phosphate), NADH (from NAD^+), and pyruvate. **3.5.B.2:** Pyruvate is transported from the cytosol to the mitochondrion where oxidation occurs. This process releases electrons during the Krebs (citric acid) cycle, reducing NAD^+ to NADH and FAD to $FADH_2$, and releasing CO_2 . **3.5.B.3:** The Krebs cycle takes place in the mitochondrial matrix. During the Krebs cycle, carbon dioxide is released from organic intermediates, ATP is synthesized from ADP and inorganic phosphate, and electrons are transferred by the coenzymes NAD^+ and FAD. **3.5.B.4** Electrons extracted in glycolysis and Krebs cycle reactions are transferred by NADH and $FADH_2$ to the ETC in the inner mitochondrial membrane. **3.5.B.5** When electrons are transferred between molecules in a sequence of reactions as they pass through the ETC, an electrochemical gradient of protons (hydrogen ions) across the inner mitochondrial membrane is established. The pH inside the mitochondrial matrix is higher than in the intermembrane space. **3.5.B.6** Fermentation allows glycolysis to proceed in the absence of oxygen and produces organic molecules such as alcohol and lactic acid.	Concept 7.2: Glycolysis harvests chemical energy by oxidizing glucose to pyruvate Concept 7.3: After pyruvate is oxidized, the citric acid cycle completes the energy-yielding oxidation of organic molecules Concept 7.4: During oxidative phosphorylation, chemiosmosis couples electron transport to ATP synthesis

				Concept 7.5: Fermentation and anaerobic respiration enable cells to produce ATP without the use of oxygen

Unit 4: Cell Communication and Cell Cycle (6 Topics)				
AP® Biology Topics	**Big Ideas**	**Learning Objectives**	**Essential Knowledge**	**Campbell Biology in Focus 4e**
4.1 Cell Communication	**Big Idea 3** Information Storage and Transmission	**4.1.A:** Describe the ways that cells can communicate with one another. **4.1.B:** Explain how cells communicate with one another over short and long distances	**4.1.A.1**: Cells communicate with one another through direct contact with other cell or from a distance via chemical signaling **4.1.B.1:** Cells communicate over short distances by using local regulators that target cells I the vicinity of the signal-emitting cell. **A1.B.2:** Signals released by one cell type can travel long distances to target cells of another type.	Concept 5.6: The plasma membrane plays a key role in most cell signaling
4.2 Introduction to Signal Transduction	**Big Idea 3** Information Storage and Transmission	**4.2.A:** Describe the components of a signal transduction pathway. **4.2.B:** Describe the role of components of a signal transduction pathway in producing a cellular response.	**4.2.A.1:** Signal transduction pathways link signal receptions with cellular responses. **4.2.A.2:** Many signal transduction pathways include protein modifications and involve phosphorylation cascades. **4.2.B.1:** Signaling begins with the recognition of a chemical messenger—a ligand—by a receptor protein in a target cell. i. The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide (protein) or a small molecule. ii. G protein-coupled receptors are an example of a receptor protein in eukaryotes. **4.2.B.2:** Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, resulting in the appropriate responses by the cell. Responses could include cell growth, secretion of molecules, or gene expression. i. After the ligand binds, the intracellular domain of a	Concept 5.6: The plasma membrane plays a key role in most cell signaling Concept 32.1: The endocrine and nervous systems act individually and together in regulating animal physiology

			receptor protein changes shape, initiating transduction of the signal. ii. Enzymes and second messengers such as cyclic AMP (cAMP) relay and amplify the intracellular signal. iii. Hormones are an example of a signaling messenger that can travel long distances in the bloodstream. iv. The binding of ligands to ligand-gated channels can cause the channel to open or close,	
4.3 Signal Transduction Pathways	**Big Idea 3** Information Storage and Transmission	**4.3.A:** Describe the different types of cellular responses elicited by a signal transduction pathway. **4.3.A:** Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway.	**4.3.A.1:** Signal transduction may result in changes in gene expressions and cell function, which may alter phenotype or result in programmed cell death (apoptosis). **4.3.B.2:** Changes in signal transduction pathways can later cellular responses Mutations in any domain of the receptor protein or in any component of the signaling pathway may affect the downstream components by altering the subsequent transduction of the signal. **4.3.B.3:** Chemicals that interact with any component of the signaling pathway may activate or inhibit the pathway.	Concept 5.6: The plasma membrane plays a key role in most cell signaling Concept 9.3: The eukaryotic cell cycle is regulated by a molecular control system Concept 16.1: A program of differential gene expression leads to the different cell types in a multicellular organism Concept 31.2: Plant hormones hep coordinate growth, development, and responses to stimuli
4.4 Feedback	**Big Idea 2** Energetics	**4.4.A:** Explain how positive and negative feedback helps maintain homeostasis.	**4.4.A.1** Organisms use feedback mechanisms to maintain their internal environments in response to internal and external changes. i. Negative feedback mechanisms maintain homeostasis by reducing the initial stimulus to regulate physiological processes. If a system is perturbed or disrupted, negative feedback mechanisms return the system back to its target set point. These processes operate at the molecular cellular, and organismal levels.	Concept 6.5: Regulation of enzyme activity helps control metabolism Concept 32.2: The endocrine and nervous systems act individually and together in regulating animal physiology Concept 32.3: Feedback

			ii. Positive feedback, mechanisms amplify responses and processes in biological organisms. The variable initiating the response is moved further away from the initial set point. Ampfliication occurs when the stimulus is further intensified, which in turn, initiates and additional response that produces system change.	control maintains. the internal environment in many animals Concept 33.5: Feedback circuits regulate. digestion, energy allocation, and appetite

AP® Biology Topics	Big Idea	Big Ideas: Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4e
4.5 Cell Cycle	**Big Idea 3** Information Storage and Transmission	**4.5.A:** Describe the events that occur in the cell cycle. **4.5.B:** Explain how mitosis results in the transmission of chromosomes from one generation of cells to the next.	**4.5.A.1:** The cell cycle is a highly regulated series of events that controls the growth and reproduction of eukaryotic cells. i. The cell cycle consists of sequential stages of interphase (G1, S, G2), mitosis, and cytokinesis. ii. G1 phase: The cell is metabolically active, duplicating organelles and cytosolic components. iii. S phase: DNA is in the form of chromatin and replicates to form two sister chromatids connected at a centromere. iv. G2 phase: Protein synthesis occurs, ATP is produced in large quantities, and centrosomes replicate. v. A cell can enter a stage (G0) in which it no longer divides, but it can reenter the cell cycle in response to appropriate cues. vi. Nondividing cells may exit the cell cycle or be held at a particular cycle **4.5.B.1:** Mitosis is a process that ensures the transfer of a complete genome from a parent cell to two genetically identical daughter cells in eukaryotes. i. Mitosis plays a role in growth, tissue repair, and asexual reproduction. ii. Mitosis occurs in sequential steps (prophase, metaphase, anaphase, telophase) and alternates with interphase in the cell	Overview: The Key Roles of Cell Division Concept 9.1 Most cell division results in genetically identical daughter cells Concept 9.2: The mitotic phase alternates with interphase in the cell cycle

			cycle. iii. Prophase: Sister chromatids condense, mitotic spindle begins to form, and centrosomes move to opposite poles of the cell. iv. Metaphase: Spindle fibers align chromosomes along the equator of the cell. v. Anaphase: Paired sister chromatids separate as spindle fibers pull chromatids toward poles. vi. Telophase: Mitotic spindle breaks down, a new nuclear envelope develops, and then the cytoplasm divides. vii. Cytokinesis: A cleavage furrow forms in animal cells or a cell plate forms in plant cells, resulting in two new daughter cells.	
4.6 Regulation of Cell Cycle	**Big Idea 3** Information Storage and Transmission	**4.6.A:** Describe the role of checkpoints in regulating the cell cycle.	**A.6.A.1:** A number of internal controls or checkpoints regulate progression through the cell cycle. **A.6.A.2:** Interactions between cyclins and cylin-dependent kinases control the cell cycle.	Concept 9.3: The eukaryotic cell cycle is regulated by a molecular control system
		4.6.B: Describe the effects of disruptions to the cell cycle on the cell or organism.	**4.6.B.1:** Disruptions to the cell cycle may result in cancer or apoptosis (programmed cell death).	Concept 16.3: Abnormal regulation of genes that affect the cell cycle can lead to cancer

AP® Biology Topics Unit 5: Heredity (5 topics)	Big Idea	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4e
5.1 Meiosis	**Big Idea 3** Information Storage and Transmission	**5.1.A:** Explain how meiosis results in the transmission of chromosomes form one generation to the next.	**5.1.A.1** Meiosis is a process that ensures the formation of haploid gamete cells, sometimes referred to as daughter cells, in sexually reproducing diploid organisms. **5.1.A.2** Meiosis I involves the following steps: i. Prophase I: Homologous chromosomes pair up and condense, synapsis occurs and then chiasmata may form, meiotic spindle begins to form, centrosomes move to opposite poles of the cell, and the nuclear envelope breaks down. ii. Metaphase I: Meiotic spindle fibers align homologous pairs of chromosomes along the equator of the cell at the metaphase plate. iii. Anaphase I: Homologous chromosomes separate, while sister chromatids remain attached, as meiotic spindle fibers pull chromosomes toward poles. iv. Telophase I: Meiotic spindle breaks down, a new nuclear envelope develops, a cleavage furrow (animal cell) or cell plate (plant cell) forms, and cytokinesis occurs. Two haploid daughter cells are formed (at the end of meiosis I). **5.1.A.3:** Meiosis II involves the fo i. Prophase II: Meiotic spin spindle. ii. Metaphase II: Chromoso of each chromatid is attac	Concept 10.1: Offspring acquire genes from parents by inheriting chromosomes Concept 10.2: Fertilization and meiosis alternate in sexual life cycles Concept 10.3: Meiosis reduces the number of chromosomes sets from diploid to haploid

			iii. Anaphase II: Proteins at the centromeres break down, ar toward opposite poles in the cell. iv. Telophase II: Meiotic spindle breaks down, a new nucle (animal cell) or a cell plate (plant cell) forms, chromatic occurs. Four haploid daughter cells are formed, each wi	
		5.1.B: Describe similarities and differences between the phases and outcomes of mitosis and meiosis	**5.1.B.1:** Mitosis and meiosis are similar in the use of a spindle a the number of cells produced and the genetic content of the daug	Figure 10.10: A comparison of mitosis and meiosis
5.2 Meiosis and Genetic Diversity	**Big Idea 3** Information Storage and Transmission	**5.2.A:** Explain how the process of meiosis generates genetic diversity.	**5.2.A.1:** Correct separation of the homologous chromosomes in meiosis I and sister chromatids in meiosis II ensures that each gamete receives a haploid (1n) set of chromosomes that comprises an assortment of both maternal and paternal chromosomes. When incorrect separation occurs (nondisjunction), gametes are no longer haploid. 5.2.A.2: During prophase I of meiosis, non-sister chromatids exchange genetic material via a process called crossing over (recombination), which increases genetic diversity among the resultant gametes. **5.2.A.3:** Sexual reproduction is eukaryotes increases genetic variation, including crossing over, random assortment of chromosomes during meiosis, and subsequent fertilization of gametes.	Concept 10.3: Meiosis reduces the number of chromosomes sets from diploid to haploid Concept 10.4: Genetic variation produced in sexual life cycles contributes to evolution

5.3 Mendelian Genetics	**Big Idea 1** Evolution	**5.3.A:** Explain the inheritance of genes and traits as described by Mendel's laws.	**5.3.A.1** Mendel's laws of segregation and independent assortment can be applied to genes that are on different chromosomes. **5.3.A.2** In most cases, fertilization involves the fusion of two haploid gametes, restoring the diploid number of chromosomes and increasing genetic variation in populations by creating new combinations of alleles in the zygote. i. Rules of probability can be applied to analyze the passing of single-gene traits from parent to offspring. ii. Monohybrid, dihybrid, and test crosses can be used to determine whether alleles are dominant or recessive. iii. An organism's genotype is the set of alleles inherited for one or more	Concept 11.1: Mendel used the scientific approach to identify tow laws of inheritance. Concept 11.2: Probability laws govern Mendelian inheritance

			genes by an individual organism. An organism's genotype can be homozygous or heterozygous for each gene. iv. An organism's phenotype is the observable expression of the inherited traits. v. Patterns of inheritance (autosomal, genetically linked, sex-linked) and whether an allele is dominant or recessive can often be predicted from data, including pedigrees. Punnett squares can be used to predict the genotypes and phenotypes of parents and offspring. **RELEVANT EQUATIONS** Laws of Probability: If *A* and *B* are mutually exclusive, then: $P(A \text{ or } B) = P(A) + P(B)$ If A and B are independent, then: $P(A \text{ and } B) = P(A) \times P(B)$ v.	Concept 11.3: Inheritance patterns are often more complex than predicted by simple Mendelian genetics Concept 11.4: Many human traits follow Mendelian patterns of inheritnace
5.4 Non-Mendelian Genetics	**Big Idea 3** Information Storage and Transmission	**5.4.A:** Explain deviations from Mendel's model of the inheritance of traits.	**5.4.A.1:** Patterns of inheritance of many traits do not follow the ratios predicted by Mendel's laws and can be identified by quantitative analysis, when the observed phenotypic ratios statistically differ from the predicted ratios. i. Genes located on the same chromosome are referred to as being genetically linked. The probability that these linked genes segregate together during meiosis can be used to calculate the map distance (or map	Concept 12.1: Mendelian inheritance has its physical basis in the behavior of chromosomes Concept 12.3: Linked genes tend to be inherited together because they are located ear each other on

			units) between them on a chromosome. This calculation is called gene or genetic mapping. ii. Codominance occurs when the phenotype from both alleles is expressed such that the heterozygote would have a different phenotype than either homozygote. iii. Incomplete dominance occurs when neither allele of a gene can mask the other, so the phenotype of the heterozygote is a blended version of the dominant and recessive phenotypes.	the same chromosome Concept 11.3: Inheritance patterns are often more complex than predicted by simple Mendelian genetics
			5.4.A.2: Some traits, known as sex-linked traits (X- or Y-linked), are determined by genes on sex chromosomes. The pattern of inheritance of sex-linked traits can often be predicted from data, including pedigrees, indicating the genotypes and phenotypes of both parents and offspring.	Concept 12.2: Sex-linked genes exhibit unique patterns of inheritance
			5.4.A.3: Pleiotropy is a phenomenon in which the expression of a single gene results in multiple traits or effects; these traits therefore do not segregate independently. **5.4.A.4:** Some traits result from non-nuclear inheritance. i. Chloroplasts and mitochondria are randomly assorted to gametes and daughter cells; thus, traits determined by chloroplast and mitochondrial DNA do not follow simple Mendelian rules. ii. In animals, mitochondria are usually transmitted	Concept 11.3: Inheritance patterns are often more complex than predicted by simple Mendelian genetics Concept 30.1:

			by the egg and not by sperm; thus, traits determined by the mitochondrial DNA are typically maternally inherited. iii. In plants, mitochondria and chloroplasts are transmitted in the ovule and not in the pollen; as such, mitochondria-determined and chloroplast-determined traits are typically maternally inherited.	Flower double fertilization, and fruits are unique features of the angiosperm life cycle Figure 36.9: Exploring Human Gametogenesis

AP® Biology Topics	Big Ideas:	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4e
5.5 Environmental Effects on Phenotype	**Big Idea 4** Systems Interactions	**5.5.A:** Explain how the same genotype can result in multiple phenotypes under different environmental conditions.	**5.5A.1:** Environmental conditions influence can expression and can lead to phenotypic plasticity (e.g., the ability of individual genotypes to produce different phenotypes.	Concept 11.3: Inheritance patterns are often more complex than predicted by simple Mendelian genetics
		Unit 6: Gene Expression and Regulation (8 Topics)		
6.1 DNA and RNA Structure	**Big Idea 3** Information Storage and Transmission	**6.1.A:** Describe the structures involved in passing hereditary information from one generation to the next. **6.1.B:** Describe the characteristics of DNA that allow it to be used as hereditary material.	**6.1.A.1:** Genetic information is stored in and passed to subsequent generations through DNA molecules and, in some cases, RNA molecules. i. Prokaryotic organisms typically have circular chromosomes. ii. Eukaryotic organisms typically have multiple linear chromosomes that are comprised of DNA. These chromosomes are condensed using histones and associated proteins. **6.1.A.2:** Prokaryotes and eukaryotes can contain plasmids, which are extra-chromosomal circular molecules of DNA. 6.1.B. Nucleic acids exhibit specific nucleotide base pairing that is conserved through evolution. i. Purines (guanine and adenine) have a double ring structure. ii. Pyrimidines (cytosine, thymine, and uracil) have a single ring structure. iii. Purines pair with pyrimidines; adenine with thymine (or uracil in RNA) and guanine with cytosine.	Concept 3.6: Nucleic acids store, transmit, and help express hereditary information Concept 24.2: Diverse structural and metabolic adaptations have evolved in prokaryotes Concept 13.2: Many proteins work together in DNA replication and repair Concept 13.3: A chromosome consists of a DNA molecule packed together with proteins. Concept 13.4: Understanding DNA structure and replication makes genetic engineering possible Concept 13.1: DNA is the genetic material

6.2 DNA Replication	**Big Idea 3** Information Storage and Transmission	**6.2.A:** Describe the mechanisms by which genetic information is copied for transmission between generations.	**6.2.A.1:** DNA replication ensures continuity of hereditary information. i. DBA is synthesized in the 5' to 3' direction. ii. Replication is a semiconservative process, meaning one strand of DNA serves as the template for a new strand of complementary DNA. iii. Helicase unwinds the DNA strands. iv. Topoisomerase relaxes supercoiling in front of the replication fork. v. DNA polymerase requires RNA primers to initiate DNA synthesis. vi. DNA polymerase synthesizes new strands of DNA continuously on the leading strand and discontinuously on the lagging strand vii. Ligase joins the fragments on the lagging strand.	Concept 13.2: Many proteins work together in DNA replication and repair
6.3 Transcriptio n and RNA Processing	**Big Idea 3** Information Storage and Transmission	**6.3.A:** Describe the mechanisms by which genetic information flows from DNA to RN to protein.	**6.3.A.1:** The sequence of the RNA bases, together with the structure of the RNA molecule, determines RN function. i. Messenger RNA (mRNA) molecules carry information from DNA in the nucleus to the ribosome in the cytoplasm. ii. Distinct transfer RNA (tRNA) molecules bind specific amino acids and have anticodon sequences that base pair with the codons of mRNA. tRNA is recruited to the ribosome during translation to generate the primary peptide sequence based on the mRNA sequence. iii. Ribosomal RNA (rRNA) molecules are functional building blocks of ribosomes. **6.3.A.2:** RNA polymerases use a single template strand of DNA to direct the inclusion of bases in the newly formed RNA molecule. This process is known as transcription. **6.3.A.3:** The enzyme RNA polymerase synthesizes mRNA molecules in the 5' to 3' direction by reading the template DNA strand in	Concept 14.1: Genes specify proteins via transcription and translation Concept 14.2: Transcription is the DNA-directed synthesis of RNA: A Closer Look

			the 3' to 5' direction. **6.3.A.4:** In eukaryotic cells the mRNA transcript undergoes a series of enzyme-mediated modifications. i. The addition of a poly-A tail makes mRNA more stable. ii. The addition of a GTP cap helps with ribosomal recognition. iii. The excision of introns, along with the splicing and retention of exons, generates different versions of the resulting mature mRNA molecule. This process is known as alternative splicing.	Concept 14.3: Eukaryotic cells modify RNA after transcription
6.4 Translation	**Big Idea 3** Information Storage and Transmission	**6.4.A:** Explain how the phenotype of an organism is determined by its genotype.	**6.A.4.1:** Translation of the mRNA to generate a polypeptide occurs on the ribosomes that are present in the cytoplasm of both prokaryotic and eukaryotic cells, as well as the cytoplasmic surface of the rough ER of eukaryotic cells. **6.A.4.2:** In prokaryotic organisms, translation of the mRNA molecule occurs while it is being transcribed. **6.A.4.3:** Translation involves many sequential steps, including initiation, elongation, and termination. The salient features of translation include: i. The translation is initiated when the rRNA in the ribosome interacts with he mRNA at the start codon (AUG, coding for the amino acid methionine). ii. The sequence of nucleotides on the mRNA is read in triplets, called codons. iii. Each codon encodes a specific amino acid, which can be deduced by using a genetic code chart. Many amino acids are encoded by more than one codon. iv. Nearly a living organisms use the same genetic code, which is evidence for the common ancestry of all living organisms. v. tRNA brings the correct amino acid	Concept 14.4: Translation is the RNA-directed synthesis of a polypeptide: A Closer Look Concept 14.1: Genes specify proteins via transcription and translation

			to the pace specified by the codon on the mRNA. vi. The amino acid is transferred to the growing polypeptide chain. vii. The process continues along the mRNA until a sop codon is reached. viii. Translation terminates with the release of the newly synthesized protein. **6.4.A.4:** Genetic information is retroviruses is a special case and has an alternate flow if information: from RNA to DNA, made possible by reverse transcriptase, an enzyme that copies the viral RNA genome into DNA. This DNA integrates in the host genome and is transcribed and translate for the assembly of new viral progeny.	Concept 17.2: Viruses replicate only in host cells

AP® Biology Topics	Big Ideas:	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4e
6.5 Regulation of Gene Expression	**Big Idea 3** Information Storage and Transmission	**6.5.A:** Describe the types of interactions that regulate gene expression 6.5.B: Explain how the location of regulatory sequences relates to their function.	**6.5.A.1:** Regulatory sequences are stretches of DNA that interact with regulatory proteins to control transcription. Some genes are constitutively expressed, and others are inducible. **6.5.A.2:** Epigenetic chances can affect gene expression through reversible modifications of DNA or histones. **6.5.A.3:** The phenotype of a cell or an organism is determined by the combination of genes that are expressed and the levels at which they are expressed. i. Observable cell differentiation results from the expression of genes for tissue-specific proteins. ii. induction of transcription factors during development results in sequential gene expression. iii. The function and amount of gene products determine the phenotype of organisms. **6.5.A.4:** Both prokaryotes and eukaryotes have groups of genes that are coordinately regulated. i. Prokaryotes regulate operons in an inducible or repressible system. ii. In eukaryotes, groups of genes may be influenced by the same transcription factors to coordinately regulate expression. **6.5.B.1:** Both prokaryotes and eukaryotes have groups of genes that are coordinately regulated. i. Prokaryotes regulate operons in an inducible or repressible system.	figure 15.1: How can two cells with the same set of genes function differently? Concept 15.2: Eukaryotic gene expression is regulated at many stages Concept 15.3: Noncoding RNAs play multiple roles in controlling gene expression Concept 15.1: Bacteria often respond to environmental change by regulating transcription. Concept 15.2: Eukaryotic gene expression is regulated at many stages Concept 15.4: Researchers can monitor expression of specific genes

			ii. In eukaryotes, groups of genes may be influenced by the same transcription factors to coordinately regulate expression,	
6.6 Gene Expression and Cell Specialization	**Big Idea 3** Information Storage and Transmission	**6.6.A:** Explain how the binding of transcription factors to promoter regions affects gene expression and the phenotype of the organism. **6.6.B:** Explain the connection between the regulation of gene expression and the phenotypic differences in cells and organisms.	**6.6.A.1:** RNA polymerase and transcription factors bind to promoter or enhancer DNA sequences to initiate transcription. These sequences can be upstream or downstream of the transcription start site. **6.6.A.2:** Negative regulatory molecules inhibit gene expression by binding to DNA and blocking transcription. **6.6 B.1:** Gene regulation results in differential gene expression and influences cell products and functions. **6.6.B.2:** Certain small RNA molecules have roles in regulating gene expression.	Concept 15.3: Noncoding RNAs play multiple roles in controlling gene expression Concept 15.4: Researchers can monitor expression of specific genes Figure 15.1: How can two cells with the same set of genes function differently? Concept 15.2: Eukaryotic bene expression is regulated at many stages Concept 15.3: Noncoding RNAs paly multiple roles in controlling gene expression Concept 16.1: A program of differential gene expression leads to the different cell types in a multicelllular organism
6.7 Mutations	**Big Idea 3** Information Storage and Transmission	**6.7.A:** Describe the various types of mutations.	**6.7.A.1:** Alterations in a DNA sequence are mutations that can cause changes in the type or amount of the protein produced and the consequent phenotype. DNA mutations can be beneficial, detrimental, or neutral based on the resulting nucleic acid or protein and the phenotypes that are conferred by the protein. i. Point mutations occur when one nucleotide has been substituted for a different nucleotide. ii. Frameshift mutations	Concept 14.5: Mutations of one or a few nucleotides can affect protein structure and function

		6.7.B: Explain how changes in genotype may result in changes in phenotype. **6.7.C:** Explain how alterations in DNA sequences contribute to variation that can be subject to natural selection.	occur when one or more nucleotides are inserted or deleted, causing the reading frame to be shifted. iii. Nonsense mutations occur when there is a point mutation that causes a premature stop. iv. Silent mutations occur when they change in the nucleotide sequence has not effect on the amino acid sequence. **6.7.B.1:** Errors in DNA replication or DNA repair mechanisms as well as external factors, including radiation and reactive chemicals, can cause random mutations in the DNA. i. Whether a mutation is beneficial, detrimental, or neutral depends on the environmental context. ii. Mutations are a source of genetic variation **6.7.B.2:** Errors in mitosis or meiosis can result in changes in phenotype. i. Changes in chromosome number resulting from nondisjunction often result in new phenotypes caused by triploidy (aneuploidy). ii. Changes in chromosome number often result in disorders with developmental limitations. iii. Alterations in chromosome structure lead to genetic disorders. **6.7.C.1:** Changes in genotype may affect phenotypes that are subject to natural selection. Genetic changes that enhance survival and reproduction can be selected for by environmental conditions. i. The horizontal acquisitions of genetic information in prokaryotes	Concept 12.4: Alterations of chromosome number or structure cause some genetic disorders Concept 20.5: New information continues to improve our understanding of evolutionary history Concept 24.3: Rapid reproduction, mutation, and genetic renominations promote genetic diversity in prokaryotes.

			via transformation (uptake of DNA), transduction (viral transmission of genetic information), conjugation (cell-to-cell transfer of DNA), and transposition (movement of DNA segments within and between DNA molecules) increase genetic variation. ii. Related viruses can recombine genetic information if they infect the same host cell. iii. Reproductive processes that increase genetic variation are evolutionarily conserved and are shared by various organisms.	
6.8 Biotechnology	**Big Idea 3** Information Storage and Transmission	**6.8.A:** Explain the use of genetic engineering techniques in analyzing or manipulating DNA	**6.8.A.1:** Genetic engineering techniques can be used to analyze and manipulate DNA and RNA. i. Gel electrophoresis is a process that separates DNA fragments by size and charge. ii. During polymerase chain reaction (PCR), DNA fragments are amplified by denaturing DNA, annealing primers to the original strand, and extending the new DNA molecule. iii. Bacterial transformation introduces foreign DNA into bacterial cells. iv. DNA sequencing technology determines the order of nucleotides in a DNA molecule. Typically, these techniques result in a DNA fingerprint that allows for the comparison of DNA sequences from various smaples.	Concept 3.7: Genomics and proteomics have transformed biological inquiry and applications Concept 13.4: Understanding DNA structure and replication makes genetic engineering possible Concept 15.4: Researchers can monitor expression of specific genes Concept 16.2: Cloning of organisms showed that differentiated cells could be "reprogrammed" and ultimately led to the production of stem cells Concept 24.5: Prokaryotes play crucial roles in the biosphere Concept 30.3: People modify crops through breeding and genetic engineering

AP® Biology Topics	Big Ideas	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4e
		Unit 7 Natural Selection (12 Topics)		
7.1 Introduction to Natural Selection	**Big Idea 1** Evolution	**7.1.A:** Describe the causes of natural selection. **7.1.B:** Explain how natural selection affects populations.	**7.1.A.1:** Natural selection is a major mechanism of evolution **7.1.A.2:** 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 on those favorable traits to subsequent generations. **7.1.B.1:** Evolutionary fitness is measured by reproductive success. **7.1.B.2:** Biotic and abiotic environments can fluctuate, affecting the rate and direction of evolution. Different genetic variations can be selected in each generation.	Figure 19.1: What causes the similarities and differences among Earth's many different species? Concept 19.1: The Darwinian revolution challenged traditional views of a young Earth inhabited by unchanging species Concept 19.2: Descent with modifications by natural selection explains the adaptations of organisms and the unity and diversity of life Concept 19.3: Evolution is supported by an overwhelming amount of scientific evidence Concept 21.4: Natural selection is the only mechanism that consistently causes adaptive evolution
7.2 Natural Selection	**Big Idea 1** Evolution	**7.2.A:** Describe the importance of phenotypic variation in a population. **7.2.B:** Explain how variation in molecules within cells connects to the fitness of an organism.	**7.2.A.1:** Natural selection acts on phenotypic variations in populations. **7.2.A.2:** Environments change and apply selective pressures to populations. **7.2.A.3:** Some phenotypic variations can increase or decrease the fitness of an organism in particular environments. **7.2.B.1:** Variation in the number and types of molecules within cells can provide populations a greater ability to survive and reproduce in different environments	Figure 21.1: What mechanisms can cause the evolution of populations? Concept 21.1: Genetic variation makes evolution possible Concept 21.4: Natural selection is the only mechanism that consistently causes adaptive evolution Figure 21.15: The Sickle-Cell Allele Concept 21.3: Natural selection, genetic drift, and gene flow can alter allele frequencies in a population

7.3 Artificial Selection	**Big Idea 1** Evolution	**7.3.A:** Explain how humans can affect diversity within a population	**7.3.A.1:** Through artificial selection, humans affect variation in other species.	Concept 19.2: Descent with modification by natural selection explains the adaptations of organisms and the unity and diversity of life Concept 30.3: People modify crops through breeding and genetic engineering.
7.4 Population Genetics	**Big Idea 1** Evolution	**7.4.A:** Explain how random occurrences affect the genetic makeup of a population. **7.4.B:** Describe the role of random processes in the evolution of specific populations	**7.4.A.1:** Evolution is also driven by random occurrences. i. Mutation is a random process that adds new genetic variation to a population. ii. Genetic drift is a change in allele frequencies attributable to a nonselective process occurring in small populations. iii. The bottleneck effect is a type of genetic drift that occurs when a population size is reduced to a small number of individuals for at least one generation. iv. The founder effect is a type of genetic drift that occurs when a population is separated from other members of the population. The frequency of genes and traits will shift based on the genes in this new founder population. V. Migration can result in gene flow (the addition or removal of alleles from a population). **7.4.B.1:** Random processes can lead to changes in allele frequencies in a	Chapter 21 Overview: The Smallest Unit of Evolution Concept 21.1: Genetic variation makes evolution possible Concept 21.3: Natural selection genetic drift, and gene flow can alter allele ffrequencies in a population

		7.4.C: Describe the change in the genetic makeup of a population over time.	population. i. Mutations result in genetic variation, which provides phenotypes on which natural selection acts. ii. Genetic drift can allow a small population to diverge from other populations of the same species. iii. Gene flow between two populations prevents them from diverging into separate species. **7.4.C.1:** Changes in allele frequencies provide evidence for the occurrence of evolution in a population.	Concept 21.4: Natural selectin is the onlyb mechanism that consistently causes adaptive evoltution
7.5 Hardy-Weinberg Equilibrium	**Big Idea 1** Evolution	**7.5.A:** Describe the conditions under which allele and genotype frequencies will change in populations.	**7.5.A.1:** The Hardy-Weinberg Equilibrium is a model for describing and predicting allele frequencies in a non-evolving population. Conditions for a population or an allele to be in Hardy-Weinberg equilibrium are i. A large population size ii. No migration iii. No new mutations iv. Random mating v. No natural selection These conditions are never met, but they provide a valuable null hypothesis **7.5.A.2:** Allele frequencies in a nonevolving population can be calculated from genotype frequencies.	Concept 21.2: The Hardy-Weinberg equation

			Relevant Equations Hardy-Weinber Equation- P2 + 2pq + q2 = 1 P + q = 1 Where p= frequency of allele 1 in the population q = frequency of allele 2 in the population	

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7.6 Evidence of Evolution	**Big Idea 1** Evolution	**7.6.A:** Describe the types of data that provide evidence for evolution. **7.6.B:** Explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time.	**7.6.A.1:** Evolution is supported by scientific evidence from many disciplines (geographical, geological, physical, biochemical, and mathematical data). **7.6 B.1:** Molecular, morphological, and genetic evidence from extant and extinct organisms adds to our understanding of evolution. i. Fossils an be dated by a variety of methods These include 1) the age of the rocks where a fossil is found; 2) the rate of decay of isotopes including cargon-14; and 3) geographical data. ii. Morphological homologies, including vestigial structures, provide evidence of common ancestry. **7.6.B.2:** A comparison of DNA nucleotide sequences and protein amino acid sequences provides evidence for evolution and common ancestry.	Concept 1.1: The study of life reveals unifying themes Concept 1.2: The Core Theme: Evolution accounts for the unity and diversity of life Concept 3.7: Genomics and proteomics have transformed biological inquiry and applications Concept 19.3: Evolution is supported by an overwhelming amount of scientific evidence Concept 23.1: The fossil record documents life's history Concept 23.2: The rise and fall of groups of organisms reflect differences in speciation and etinction rates Concept 17.3: Viruses and prions are formidable pathogens in animals and plants include: Scientific Skills Exercise: Analyzing a Sequence-Based Phylogenetic Tree to Understand Viral Evolution
7.7 Common Ancestry	**Big Idea 1** Evolution	**EVO: 7.7.A:** Describe structural and functional evidence on cellular and molecular levels that provides evidence for the common ancestry of all eukaryotes.	**7.7.A.1:** Structural and function evidence indicates common ancestry of all eukaryotes. This evidence includes: i. Membrane-bound organelles ii. Linear chromosomes iii. Genes that contain introns	Concept 4.2: Eukaryotic cells have internal membranes that compartmentalize their functions Concept 4.5: Mitochondria and chloroplasts change energy from one form to another Concept 24.2: Diverse structural and metabolic adaptations have evolved in prokaryotes Concept 25.1: Eukaryotes arose by endosymbiosis more than 1.8 billion years ago Concept 14.1: Genes specify proteins via transcription and translation

7.8 Continuing Evolution	**Big Idea 1** Evolution	**EVO: 7.8.A:** Explain how evolution is an ongoing process in all living organisms.	**7.8.A.1:** All species have evolved and continue to evolve. Examples include: i. Genomic changes over time ii. Continuous change in the fossil record iii. Evolution of resistance to antibiotics, pesticides, herbicides or chemotherapy drugs iv. Pathogens evolving and causing emergent diseases.	Concept 19.2: Descent with modification by natural selection explains the adaptations of organisms and the unity and diversity of life Concept 19.3: Evolution is supported by an overwhelming amount of scientific evidence
7.9 Phylogeny	**Big Idea 1** Evolution	**7.9.A:** Describe the types of evidence that can be used to infer an evolutionary relationship. 7.9.B: Explain how phylogenetic trees and cladograms can be used to infer evolutionary relatedness.	**7.9.A.1:** Phylogenetic trees and cladograms show hypothetical evolutionary relationships among lineages that can be tested. **7.9.A.2:** Phylogenetic trees show the amount of change over time calibrated by fossils or a molecular clock, whereas cladograms do not show time scale of the evolutionary difference between groups. **7.9.A.3:** Traits that are either gained or lost during evolution can be used to construct phylogenetic trees and cladograms. The out-group represents the lineage that is east closely related to the remainder of the organisms in the phylogenetic tree or cladogram. i. Shared derived characters can be present in more than one lineage and indicate common ancestry. These are informative for the construction of phylogenetic trees and cladograms. ii. Molecular data typically provide more accurate and reliable evidence than morphological traits in the construction of phylogenetic trees or cladograms. **7.9.B.1:** Phylogenetic trees and cladograms can be used to illustrate speciation that has occurred. The nodes on a tree represent the most recent common ancestor of any two groups or lineages.	Chapter 20 Figure 20.1: How do biologists distinguish and categoriez the millions of species on Earth? Concept 20.1: Phylogenies show evolutionary relationships Concept 20.4: Molecular clocks help track evolutionary time Concept 20.2: Phylogenies can be used to understand shared characters Concept 20.3: Phylogenies are inferred from morphological and molecular data Concept 20.2: Phylogenies can be used to understand shared characters Concept 20.5: New information continues to improve our understanding of evolutionary history

			7.9.B.2: Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species and from DNA and protein sequence similarities. **7.9.B.3:** Phylogenetic trees and cladograms represent hypotheses that are constantly being revised based on evidence.	
7.10 Speciation	**Big Idea 1** Evolution	**7.10.A:** Describe the conditions underwhich new species may arise. **7.10.B:** Describe the rate of evolution and speciation under different ecological conditions **7.10.C:** Explain the processes and mechanisms that drive speciation.	**7.10.A.1:** Speciation occurs when two populations become reproductively isolated from each other. **7.10.A.2:** The biological species concept provides a commonly used definition of a species for sexually reproducing organisms. It states that species can be defined as a group capable of interbreeding and exchanging genetic information to produce viable, fertile offspring. **7.10.B.1:** Punctuated equilibrium is when evolution occurs rapidly after a long period of stasis. Gradualism is when evolution occurs slowly over hundreds of thousands or millions of years. **7.10.B.2:** Divergent evolution occurs when adaptation to new habitats results in phenotypic diversification. Speciation rates can be especially rapid during times of adaptive radiation as new habitats become available. **7.10.B.3:** Convergent evolution occurs when similar selective pressures result in similar phenotypic adaptations in different populations or species. **7.10.C.1:** Sympatric speciation occurs in populations with geographic overlap. Allopatric speciation occurs in populations that are	Chapter 22 Figure 22.1: How do new species originate from existing species? Concept 22.1: The biological species concept emphasizes reproductive isolation Concept 22.4: Speciation can occur rapidly or slowly and can result from changes in few or many genes Concept 19.3: Evolution is supported by overwhelming amount of scientific evidence. Concept. 22.2: Speciation can take place with or without geographic separation Concept 22.3: Hybrid zones reveal factors that cause reproductive isolation Concept 22.1: The biological species concept emphasizes reproductive isolation

			geographically isolated. **7.10.C.2:** Various pre-zygotic and post-zygotic mechanisms can maintain reproductive isolation and prevent gene flow between populations.	

AP® Biology Topics	Big Ideas	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4e
7.11 Variations in Populations	**Big Idea 4** Systems Interactions	**7.11.A:** Explain how the genetic diversity of a species or population affects its ability to withstand environmental pressures.	**7.11.A.1:** The level of variation in a population affects population dynamics. i. The ability of a population to respond to changes in the environment is influenced by genetic diversity. Species and populations with little genetic diversity are at risk of decline or extinction. ii. Genetically diverse populations are more resilient to environmental perturbation because they are more likely to contain individuals that can withstand the environmental pressure. iii. Alleles that are adaptive in one environmental condition may be deleterious I another because of different selective pressures.	Concept 43.1: Human activities threaten Earth's biodiversity Concept 43.2: Population conservation focuses on population size, genetic diversity, and critical habitat Concept 19.2: Descent with modification by natural selection explains the adaptations of organisms and the unity and diversity of life.

7.12 Origins of Life on Earth	**Big Idea 4** Systems Interactions	**7.12.A**: Describe the scientific evidence that supports models of the origin of life on Earth.	**7.12.A.1:** The origin of life on Earth is supported by scientific evidence. i. Geological evidence reinforces models of the origin of life on Earth. ii. Earth formed approximately 4.6 billion years ago (bya). The environment was too hostile for life until about 3.9 bya, and the earliest fossil evidence for life dates to 3.5 bya. Taken together, this evidence provides a plausible range of dates for the origin of life. **7.12.A.2:** The RNA world hypothesis proposes that RNA could have been the earliest genetic material. There are three assumptions: i. At some point in time, genetic continuity was assured by the replication of RNA. ii. Base-pairing is necessary for replication. iii. Genetically encoded proteins were not involved as catalysts.	Concept 24.1: Conditions on early Earth made the origin of life possible

AP® Biology Topics	Big Ideas	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4e
		Unit 8: Ecology (7 Topics)		
8.1 Responses to the Environment	**Big Idea 2** Energetics	**8.1.A:** Explain how the behavioral and physiological response of an organism is related to changes in internal or external environment.	**8.1.A.1:** Organisms respond to changes in their environment through behavioral and physiological mechanisms	Concept 31.1: Plants are highly sensitive to environmental stimuli that initiate specific behaviors. Concept 31.2: Plant hormones help coordinate growth, development, and responses to stimuli. Concept 31.3 :Responses to light are critical for plant success Concept 31.4: Plants respond to a wide variety of stimuli other than light
			8.1.A.2: Organisms exchange information with one another in response to internal changes and external cues, which can change behavior.	Concept 31.5: Plants respond to attacks by herbivores and pathogens Chapter 32, Figure 32.1: How do animals regulate their internal state even in changing or harsh environments? Concept 32.2: The endocrine and nervous systems act individually and together in regulating animal physiology Concept 32.3: Feedback control maintains the internal environment in many animals
	Big Idea 3 Information Storage and Transmission	**8.1.B:** Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of a population.	**8.1.B.1:** Organisms communicate through various mechanisms (visual, audible, tactile, electrical, and/or chemical signals). i. Organisms have a variety of signaling behviors that produce changes in the behavior of other organisms and can result in differential reproductive success. ii.Animals use sginals to indicate dominance, find food, establish territory, and ensure reproductive success.	Chapter 39, Figure 39.1: What questions do biologists seek to answer in studying animal behavior? Concept 39.3: Discrete sensory inputs can stimulate both simple and complex behaviors Concept 39.4: Learning establishes specific links between experience and behavior Concept 39.5: Selection for individual survival and reproductive success can explain diverse behaviors

			8.1.B.2: Responses to information and communication of information are vital to natural selection and evolution. i. Fitness favors innate and learned behaviors that increase survival and reproductive success. ii. Cooperative behavior tends to increase the fitness of the individual and the survival of the population.	
8.2 Energy Flow Through Ecosystems	**Big Idea 2** Energetics	**8.2.A:** Describe the strategies organisms use to acquire and use energy. **8.2.B:** Explain how energy flows and matter cycles through trophic levels.	**8.2.A.1:** Organisms use energy to organize, grow, reproduce, and maintain homeostasis. i. Organisms use different strategies to regulate body temperature and metabolism. Endotherms use thermal energy generated by metabolism to maintain homeostatic body temperatures. Ectotherms lack efficient internal mechanisms for maintaining body temperature, although they may regulate their temperature behaviorally by moving into the sun or shade or by aggregating with other individuals. ii.A net gain in energy results in energy storage, the growth of an organism, and increased reproductive output. iii. A net loss of energy results in loss of mass, a decrease in reproductive output, and, eventually, the death of an organism. **8.2.A.2:** Different organisms use various reproductive strategies in response to energy availability. Some	Concept 32.3: Feedback control maintains the internal environment in many animals Concept 33.5: Feedback circuits regulate digestion, energy allocation, and appetite Concept 40.4: Biotic and abiotic factors affect population density, dispersion, and demographics Chapter 40, figure 40.2: Exploring the Scope of Ecological Research Concept 40.1: Earth's climate influences the distribution of terrestrial biomes Concept 42.4 :Biological and geochemical processes cycle nutrients and water in ecosystems.

			organisms alternate between asexual and sexual reproduction in response to energy availability.	
			8.2.B.1: Ecological levels of organization include populations, communities, ecosystems, and biomes.	Concept 40.6: Population dynamics are influenced strongly by life history traits and population density
			8.2.B.2: Energy flows through ecosystems, while matter and nutrients cycle between the environment and organisms via biogeochemical cycles. The cycles are essential for life, and each cycle demonstrates the conservation of matter. The cycles are interdependent.	
			8.2.B.3: Biogeochemical cycles include abiotic and biotic reservoirs, as well as processes that cycle matter between reservoirs.	
			8.2.B.4: The hydrologic (water) cycle involves water movement and storage within the hydrosphere. Reservoirs include oceans, surface water, the atmosphere, and living organisms. Processes include evaporation, condensation, precipitation, and transpiration.	
		8.2.C: Explain how changes in energy availability affect populations, communities, and ecosystems.	**8.2.B.5:** The carbon cycle involves recycling carbon atoms t:hrough Earth's biosphere into organisms as carbohydrates and back into the atmosphere as carbon dioxide (CO_2). At the highest levels of organization, the carbon cycle can be simplified	Concept 42.1: Physical laws govern energy flow and chemical cycling in ecosystems Concept 42.2: Energy and other limiting factors control primary production in ecosystems Concept 41.2: Biological communities can be characterized by their diversity

		8.2.D: Explain how the activities of autotrophs and heterotrophs enable the flow of energy within and ecosystem.	into four parts: photosynthesis, cellular respiration, decomposition, and combustion. **8.2.B.6:** The nitrogen cycle involves several steps, including nitrogen fixation, assimilation, ammonification, nitrification, and denitrification. These steps are performed by microorganisms in the soil. The largest reservoir of nitrogen is the atmosphere. In nitrogen fixation, nitrogen gas (N_2) is fixed into ammonia (NH_3), which ionizes to ammonium (NH_4^+) by acquiring hydrogen ions from the soil solution. **8.2.B.7:** The phosphorus cycle involves weathering rocks releasing phosphate (PO_4^{3-})into soil and groundwater. Producers take in phosphate, which is incorporated into biological molecules; consumers eat producers, transferring phosphate to animals. Phosphorus returns to the soil via decomposition of biomass, or excretion. Phosphate can also be incorporated back into the environment via decomposition of decaying organic matter. **8.2.C.1:** Changes in energy availability can result in changes in population size. **8.2.C.2:** Changes in energy availability can result in disruptions to an ecosystem.	and trophic structure Concept 42.3: Energy transfer between trophic levels is typically only 10% efficient Chapter 40 Figure 40.1: What are the dynamics of energy and matter in an ecosystem? Concept 8.1: Photosynthesis feeds the biosphere

			i. A change in energy resources such as sunlight can affect the number and size of the trophic levels. Trophic levels include producers; primary, secondary, tertiary, and quaternary consumers; and decomposers. ii. A change in the biomass or number of producers in a given geographic area can affect the number and size of other trophic levels. **8.2.D.1:** Autotrophs capture energy from physical or chemical sources in the environment. i. Photosynthetic organisms capture energy present in sunlight contributing to primary productivity. ii. Chemosynthetic organisms capture energy from small inorganic molecules present in their environment, which can occur in the absence of oxygen. **8.2.D.2:** Heterotrophs, which include carnivores, herbivores, omnivores, decomposers, and scavengers, metabolize carbohydrates, lipids, and	

			proteins as sources of energy. Heterotrophs capture the energy present in carbon compounds by consuming organic matter derived from autotrophs incorporating matter into their tissues.	

AP® Biology Topics	Big Idea	Learning Objectives	Essential Knowledge	Campbell Biology in Focus 4e
8.3 Population Ecology	**Big Idea 4** Systems Interactions	**8.3.A:** Describe factors that influence growth dynamics of populations.	**8.3.A.1** Populations comprise individual organisms of the same species that interact with one another and with the environment in complex ways. **8.3.A.2** Many adaptations in organisms are related to obtaining and using energy and matter in a particular environment. i. Population growth dynamics depend on birth rate, death rate, and population size. **RELEVANT EQUATION** Population Growth— dN $= B - D\ dt$ where dt =chageintime B = birth rate D =deathrate N = population size dN =changeinpopulationsize ii. Reproduction without constraints results in the exponential growth of a population. **RELEVANT EQUATION** Exponential Growth— dN $= r_{max}\ N\ dt$ where dt =changeintime N =populationsize dN = change in population size r_{max} = maximum per capita growth	Concept 40.4: Biotic and abiotic factors affect population density, dispersion, and demographics Concept 40.5: The exponential and logistic models describe the growth of populations

			rate of population	
8.4 Effect of Density of Populations	**Big Idea 4** Systems Interactions	**8.4.A:** Explain how the density of a population affects and is determined by resource availability in the environment.	**8.4.A.1:** Carrying capacity is the sustainable abundance of a species that can be supported by the ecosystem's total available resources. **8.4.A.2:** As limits to growth attributable to density- dependent and density-independent factors are imposed, a logistic growth model typically ensues. **RELEVANT EQUATION** Logistical Growth— $dN_{=r\ N} K{-}N\ dt^{max}\ K$ where dt =changeintime N =populationsize dN =changeinpopulationsize r_{max} = maximum per capita growth rate of population K =carryingcapacity	Concept 40.4: Biotic and abiotic factors affect population density, dispersion, and demographics Concept 40.5: The exponential and logistic models describe the growth of populations Concept 40.6: Population dynamics are influenced strongly by life history traits and population density Concept 43.5: The human population is no longer growing exponentially but is still increasing rapidly
8.5 Community Ecology	**Big Idea 2** Energetics	**8.5.A:** Describe the structure of a community according to its species composition and diversity.	**8.5.A.1:** The structure of a community is measured and described in terms of species composition and species diversity. **RELEVANT EQUATION** Simpson's Diversity Index— 2 Diversity Index = 1 ^{n}	Concept 41.4: Interactions between species may help, harm, or have no effect on the individuals involved Conceept 43.2: Population conservation focuses on population size, genetic diversity, and critical habitat

			where N n = total number of organisms of a particular species N =totalnumberoforganismsofall species	
		8.5.B: Explain how interactions within and among populations influence community structure.	**8.5.B.1:** Communities are groups of interacting populations of different specie on the interactions between those populations. **8.5.B.2:** Interactions among populations determine how they access energy and matter within a community. **8.5.B.3:** Relationships among interacting populations can be characterized by can be modeled. Examples include predator/prey interactions, cooperation, tro partitioning. **8.5.B.4:** Competition, predation, and symbioses, including parasitism, mutuali drive population dynamics.	Chapter 41: Figure 41.1: What are some factors that influence the structure of a community? Concept 41.2: Biological communities can be characterized by their diversity and trophic structure Concept 41.1: Interactions between species may help, harm or have no effect on the individuals involved
8.6 Biodiversity	**Big Idea 4** Systems Interactions	**8.6.A:** Describe the relationship between ecosystem diversity and its resilience to changes in the environment. **8.6.B:** Explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long-term structure.	**8.6.A.1:** Natural and artificial ecosystems with fewer component parts, and with little diversity among the parts, are often less resilient to changes in the environment. **8.6.A.2:** Keystone species, producers, and essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem. **8.6.B.1:** The effects of keystone species on the ecosystem are disproportionate relative to their abundance in the ecosystem. When they are removed from the ecosystem, it often collapses.	Concept 41.3: Disturbance influences species diversity and composition Concept 41.2: Biological communities can be characterized by their diversity and trophic structure
8.7 Disruptions in Ecosystems	**Big Idea 1** Evolution **Big Idea 4** Systems	**8.7.A:** Explain the interaction between the environment and random or preexisting variations in populations.	**8.7.A.1:** An adaptation is a genetic variation that is favored by selection and manifests as a trait that provides an advantage to an organism in a particular environment. **8.7.A.2:** Heterozygote advantage is when the heterozygous genotype has a higher relative fitness than either the homozygous dominant or homozygous recessive genotype. **8.7.A.3:** Mutations are not directed by specific environmental	Concept 21.4: Natural selection is the only mechanism that consistently causes adaptive evolution Concept 21.3: Natural selection, genetic drift, and gene flow can alter allele frequencies in a population Concept 41.3: Disturbance influences species diversity and composition Concept 41.5: Pathogens alter

	Interactions	**8.7.B:** Explain how invasive species affect ecosystem dynamics. **8.7.C:** Describe human activities that lead to changes in ecosystem structure and dynamics. **8.7.D:** Explain how geological and meteorological activity leads to changes in ecosystem structure and dynamics.	pressures. **8.7.B.1:** The intentional or unintentional introduction of an invasive species can allow the species to exploit a new niche free of predators or coopetitors or to outcompete native species for resources. **8.7.C.1:** Human impact accelerates changes at the local and global levels. These activities can drive changes in ecosystems, such as the following that cause extinctions to occur i. Biomagnification ii. Eutrophication **8.7.D.1:** Geological and meteorological events affect habitat change and ecosystem distribution. Biogeographical studies illustrate these changes.	community structure locally and globally Concept 43.4: Earth is changing rapidly as a result of human actions Concept 41.4: Biogeographic factors affect community diversity Chapter 43, Figure 43.1: How can we protect the many species threatened by human activities? Concept 43.1: Human activities threaten Earth's biodiversity Concept.43.3: Landscape and regional conservation help sustain biodiversity Concept 43.4: Earth is changing rapidly as a result of human actions Concept 43.6: Sustainable development can improve human lives while conserving biodiversity