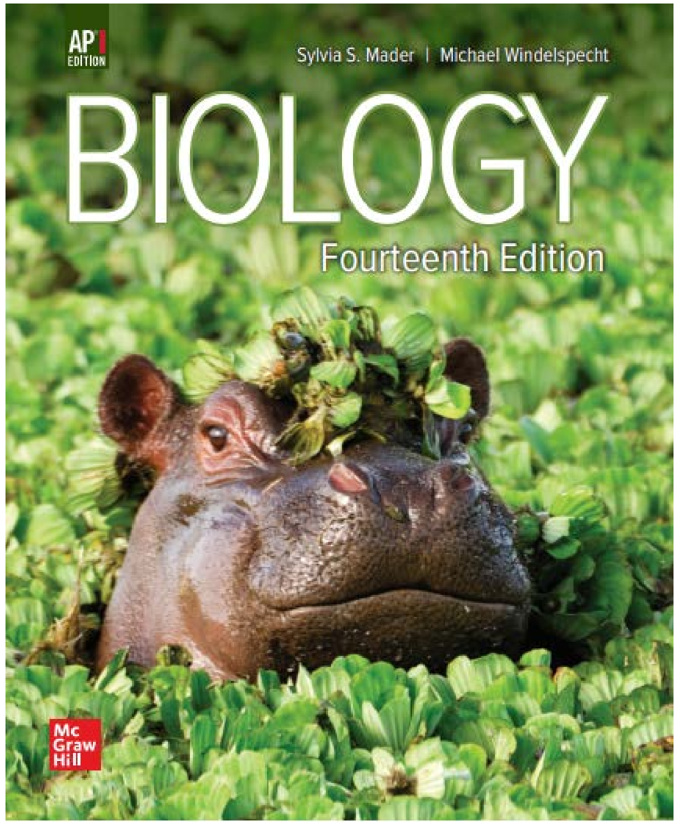

- National -

Advanced Placement* CORRELATION GUIDE

Biology

By Sylvia Mader & Michael Windelspecht

14th Edition, © 2022
ISBN 978-1-26-432660-0

Based on College Board Course Framework Articulation :
AP Biology, Effective Fall 2020

Unit 1: Chemistry of Life-8-11%

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
1.1: Structure of Water and Hydrogen Bonding	**SYI-1:** Living systems are organized in a hierarchy of structural levels that interact.	**SYI-1.A:** Explain how the properties of water that result from its polarity and hydrogen bonding affect its biological function.	**SYI-1.A.1:** The subcomponents of biological molecules and their sequence determine the properties of that molecule.	Chapter 3; Chapter 12	38-52; 203-210	**2.A:** Describe relationships between components of a visual representation (of a concept, process, or model).	Chapter 2, p. 30, Check Your progress, q. 1, 2
			SYI-1.A.2: Living systems depend on properties of water that result from its polarity and hydrogen bonding.	Chapter 2	27-30		
			SYI-1.A.3: The hydrogen bonds between water molecules result in cohesion, adhesion, and surface tension.	Chapter 2; Chapter 25	29-30; 456-457		
1.2: Elements of Life	**ENE-1:** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.	**ENE-1.A:** Describe the composition of macromolecules required by living organisms.	**ENE-1.A.1:** Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.	Chapter 2; Chapter 4; Chapter 25; Chapter 34; Chapter 45	20; 56-59; 445-446, 449-452; 623, 634-636; 842-851	**2.A:** Describe relationships between components of a visual representation (of a concept, process, or model).	Chapter 3, p. 54, AP Assessment, q. 7, 9
			ENE-1.A.2: Atoms and molecules from the environment are necessary to build new molecules –	Chapter 2; Chapter 3	20-30; 36-52		
			a. Carbon is used to build biological molecules such as carbohydrates, proteins, lipids, and nucleic acids. Carbon is used in storage compounds and cell formation in all organisms.	Chapter 2; Chapter 3; Chapter 4	20-21, 25-27; 36-42; 72-73		
			b. Nitrogen is used to build proteins and nucleic acids. Phosphorus is used to build nucleic acids and certain lipids.	Chapter 2; Chapter 3; Chapter 4; Chapter 5	20; 42-52; 60-67; 79-82		
1.3: Introduction to Biological Macromolecules	**SYI-1:** Living systems are organized in a hierarchy of structural levels that interact.	**SYI-1.B:** Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules.	**SYI-1.B.1:** Hydrolysis and dehydration synthesis are used to cleave and form covalent bonds between monomers. *Exclusion Statement--The molecular structure of specific nucleotides and amino acids is beyond the scope of the AP Exam.* *Exclusion Statement--The molecular structure of specific carbohydrate polymers is beyond the scope of the AP Exam.*	Chapter 3	37-51	**2.A:** Describe relationships between components of a visual representation (of a concept, process, or model).	Chapter 3, p. 53 AP Assessment, q. 1

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
1.4: Properties of Biological Macromolecules	**SYI-1:** Living systems are organized in a hierarchy of structural levels that interact.	**SYI-1.B:** Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules.	**SYI-1.B.2:** Structure and function of polymers are derived from the way their monomers are assembled –	Chapter 3	38-51	**1.A:** Describe biological concepts and/or processes.	Chapter 3, p. 55, AP Assessment, q. 8
			a. In nucleic acids, biological information is encoded in sequences of nucleotide monomers. Each nucleotide has structural components: a five-carbon sugar (deoxyribose or ribose), a phosphate, and a nitrogen base (adenine, thymine, guanine, cytosine, or uracil). DNA and RNA differ in structure and function.	Chapter 3	50-51		
			b. In proteins, the specific order of amino acids in a polypeptide (primary structure) determines the overall shape of the protein. Amino acids have directionality, with an amino (NH_2) terminus and a carboxyl (COOH) terminus. The R group of an amino acid can be categorized by chemical properties (hydrophobic, hydrophilic, or ionic), and the interactions of these R groups determine structure and function of that region of the protein.	Chapter 3	46-49		
			c. Complex carbohydrates comprise sugar monomers whose structures determine the properties and functions of the molecules.	Chapter 3	38-42		
			d. Lipids are nonpolar macromolecules - **i.** Differences in saturation determine the structure and function of lipids. **ii.** Phospholipids contain polar regions that interact with other polar molecules, such as water, and with nonpolar regions that are often hydrophobic. *Exclusion Statement – The molecular structure of specific lipids is beyond the scope of the AP Exam.*	Chapter 3	42-45		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
1.5: Structure and Function of Biological Macromolecules	**SYI-1:** Living systems are organized in a hierarchy of structural levels that interact.	**SYI-1.C:** Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule.	**SYI-1.C.1:** Directionality of the subcomponents influences structure and function of the polymer –	Chapter 3	36-52	**6.E.b:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	Chapter 3, p. 54, AP Assessment, q. 6
			a. Nucleic acids have a linear sequence of nucleotides that have ends, defined by the 3' hydroxyl and 5' phosphates of the sugar in the nucleotide. During DNA and RNA synthesis, nucleotides are added to the 3' end of the growing strand, resulting in the formation of a covalent bond between nucleotides.	Chapter 3; Chapter 12	50-51; 203-206		
			b. DNA is structured as an antiparallel double helix, with each strand running in opposite 5' to 3' orientation. Adenine nucleotides pair with thymine nucleotides via two hydrogen bonds. Cytosine nucleotides pair with guanine nucleotides by three hydrogen bonds.	Chapter 3; Chapter 12	50-51; 203-206		
			c. Proteins comprise linear chains of amino acids, connected by the formation of covalent bonds at the carboxyl terminus of the growing peptide chain.	Chapter 3; Chapter 12	46-47; 209-210		
			d. Proteins have primary structure determined by the sequence order of their constituent amino acids, secondary structure that arises through local folding of the amino acid chain into elements such as alpha-helices and beta-sheets, tertiary structure that is the overall three-dimensional shape of the protein and often minimizes free energy, and quaternary structure that arises from interactions between multiple polypeptide units. The four elements of protein structure determine the function of a protein.	Chapter 3	48-49		
			e. Carbohydrates comprise linear chains of sugar monomers connected by covalent bonds. Carbohydrate polymers may be linear or branched.	Chapter 3	36-42		
			Illustrative Example: Cellulose versus starch versus glycogen	Chapter 3	42		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
1.6: Nucleic Acids	**IST-1:** Heritable information provides for continuity of life.	**IST-1.A:** Describe the structural similarities and differences between DNA and RNA.	**IST-1.A.1:** DNA and RNA molecules have structural similarities and differences related to their function –	Chapter 3	50-51	**2.A:** Describe relationships between components of a visual representation (of a concept, process, or model).	Chapter 3, p. 54, AP Assessment, q. 7
			a. Both DNA and RNA have three components—sugar, a phosphate group, and a nitrogenous base—that form nucleotide units that are connected by covalent bonds to form a linear molecule with 5' and 3' ends, with the nitrogenous bases perpendicular to the sugar-phosphate backbone.	Chapter 3; Chapter 12	50-51; 203-205		
			b. The basic structural differences between DNA and RNA include the following-- **i.** DNA contains deoxyribose and RNA contains ribose. **ii.** RNA contains uracil and DNA contains thymine. **iii.** DNA is usually double stranded; RNA is usually single stranded. **iv.** The two DNA strands in double-stranded DNA are antiparallel in directionality.	Chapter 3	50-51		

Unit 2: Cell Structure and Function
10-13%

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
2.1: Cell Structure - Subcellular Components	**SYI-1:** Living systems are organized in a hierarchy of structural levels that interact.	**SYI-1.D:** Describe the structure and/or function of subcellular components and organelles.	**SYI-1.D.1:** Ribosomes comprise ribosomal RNA (rRNA) and protein. Ribosomes synthesize protein according to mRNA sequence.	Chapter 4; Chapter 12	66-67; 208-210	**1.A:** Describe biological concepts and/or processes.	Chapter 4, p. 73, Check Your Progress, q. 3
			SYI-1.D.2: Ribosomes are found in all forms of life, reflecting the common ancestry of all known life.	Chapter 4	66-67		
			SYI-1.D.3: Endoplasmic reticulum (ER) occurs in two forms – smooth and rough. Rough ER is associated with membrane-bound ribosomes-- **a.** Rough ER compartmentalizes the cell. **b.** Smooth ER functions include detoxification and lipid synthesis. *Exclusion Statement--Specific functions of smooth ER in specialized cells are beyond the scope of the course and the AP Exam.*	Chapter 4	67		
			SYI-1.D.4: The Golgi complex is a membrane-bound structure that consists of a series of flattened membrane sac –	Chapter 4	67-68		
			a. Functions of the Golgi include the correct folding and chemical modification of newly synthesized proteins and packaging for protein trafficking.	Chapter 4; Chapter 5	67-68; 89		
			Illustrative Example: • Glycosylation and other chemical modifications of proteins that take place within the Golgi and determine protein function or targeting. *Exclusion Statement – The role of the Golgi in the synthesis of specific phospholipids and the packaging of specific enzymes for lysosomes, peroxisomes and secretory vesicles are beyond the scope of the course and the AP Exam.*	Chapter 4; Chapter 5	68; 89		
			SYI-1.D.5: Mitochondria have a double membrane. The outer membrane is smooth, but the inner membrane is highly convoluted, forming folds.	Chapter 4	71-72		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
			SYI-1.D.6: Lysosomes are membrane-enclosed sacs that contain hydrolytic enzymes.	Chapter 4	68-69		
			SYI-1.D.7: A vacuole is a membrane-bound sac that plays many and differing roles. In plants, a specialized large vacuole serves multiple functions.	Chapter 4	70-71		
			SYI-1.D.8: Chloroplasts are specialized organelles that are found in photosynthetic algae and plants. Chloroplasts have a double outer membrane.	Chapter 4	71-72		
2.2: Cell Structure and Function	**SYI-1:** Living systems are organized in a hierarchy of structural levels that interact.	**SYI-1.E:** Explain how subcellular components and organelles contribute to the function of the cell.	**SYI-1.E.1:** Organelles and subcellular structures, and the interactions among them, support cellular function –	Chapter 4	62-73	**6.A:** Make a scientific claim.	Chapter 4, p. 77, AP Assessment, q. 4
			a. Endoplasmic reticulum provides mechanical support, carries out protein synthesis on membrane-bound ribosomes, and plays a role in intracellular transport.	Chapter 4	67		
			b. Mitochondrial double membrane provides compartments for different metabolic reactions.	Chapter 4	71-72		
			c. Lysosomes contain hydrolytic enzymes, which are important in intracellular digestion, the recycling of a cell's organic materials, and programmed cell death (apoptosis).	Chapter 4	68-69		
			d. Vacuoles have many roles, including storage and release of macromolecules and cellular waste products. In plants, it aides in retention of water for turgor pressure.	Chapter 4	70-71		
		SYI-1.F: Describe the structural features of a cell that allow organisms to capture, store, and use energy.	**SYI-1.F.1:** The folding of the inner membrane increases the surface area, which allows for more ATP to be synthesized.	Chapter 4; Chapter 8	72-73; 131	**6.A:** Make a scientific claim.	Chapter 8, p. 139, AP Assessment, q. 11
			SYI-1.F.2: Within the chloroplast are thylakoids and the stroma.	Chapter 4; Chapter 7	71; 110-111		
			SYI-1.F.3: The thylakoids are organized in stacks, called grana.	Chapter 4; Chapter 7	71; 110-111		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
			SYI-1.F.4: Membranes contain chlorophyll pigments and electron transport proteins that comprise the photosystems.	Chapter 4; Chapter 7	71; 110-111		
			SYI-1.F.5: The light-dependent reactions of photosynthesis occur in the grana.	Chapter 7	110-117		
			SYI-1.F.6: The stroma is the fluid within the inner chloroplast membrane and outside of the thylakoid.	Chapter 7	110-111		
			SYI-1.F.7: The carbon fixation (Calvin-Benson cycle) reactions of photosynthesis occur in the stroma.	Chapter 7	113, 117-120		
			SYI-1.F.8: The Krebs cycle (Citric Acid Cycle) reactions occur in the matrix of the mitochondria.	Chapter 8	132-133		
			SYI-1.F.9: Electron transport and ATP synthesis occur on the inner mitochondrial membrane.	Chapter 4; Chapter 8	72; 133-135		
2.3: Cell Size	**ENE-1:** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.	**ENE-1.B:** Explain the effect of surface area-to-volume ratios on the exchange of materials between cells or organisms and the environment.	**ENE-1.B.1:** Surface area-to-volume ratios affect the ability of a biological system to obtain necessary resources, eliminate waste products, acquire or dissipate thermal energy, and otherwise exchange chemicals and energy with the environment. *Relevant Equations--* Volume of a sphere: $V = 4/3\pi r^3$ Volume of a cube: $V = s^2$ Volume of a rectangular solid: $V = lwh$ Volume of a cylinder: $V = \pi r^2 h$ Surface area of a sphere: $SA = 4\pi r^2$ Surface area of a cube: $SA = 6s^2$ Surface area of a rectangular solid: $SA = 2lh + 2lw + 2wh$ Surface area of a cylinder: $SA = 2\pi rh + 2\pi r^2$ r = radius l = length h = height w = width s = length of one side of a cube	Chapter 4	57	**5.A.d:** Perform mathematical calculations, including ratios.	Chapter 4, p. 77, AP Assessment, q. 1 Chapter 4, p. 78, AP Assessment, q. 10

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
			ENE-1.B.2: The surface area of the plasma membrane must be large enough to adequately exchange materials–	Chapter 4	Chapter 4		
			a. These limitations can restrict cell size and shape. Smaller cells typically have a higher surface area-to-volume ratio and more efficiently exchange materials with the environment.	Chapter 4	57		
			b. As cells increase in volume, the relative surface area decreases and the demand for internal resources increases.	Chapter 4; Chapter 25; Chapter 34	57; 457-458; 627-628		
			c. More complex cellular structures (e.g., membrane folds) are necessary to adequately exchange materials with the environment.	Chapter 4; Chapter 34	57, 60, 62, 65, 70; 627-628		
			d. As organisms increase in size, their surface area-to-volume ratio decreases, affecting properties, like rate of heat exchange, with the environment.	Chapter 4; Chapter 18	57; 324		
			Illustrative Examples: • Root hair cells	Chapter 24	425-426		
			•Guard cells	Chapter 25	457-458		
			• Gut epithelial cells	Chapter 34	627-628		
		ENE-1.C: Explain how specialized structures and strategies are used for the efficient exchange of molecules to the environment.	**ENE-1.C.1:** Organisms have evolved highly efficient strategies to obtain nutrients and eliminate wastes. Cells and organisms use specialized exchange surfaces to obtain and release molecules from or into the surrounding environment.	Chapter 4; Chapter 6; Chapter 7; Chapter 20; Chapter 21; Chapter 24; Chapter 25; Chapter 28; Chapter 34; Chapter 45	67-72; 106-107; 110-122; 358-362; ; 429-433; 449-458; 516-520; 623-633; 837-845	**5.A.d:** Perform mathematical calculations, including ratios.	Chapter 25, p. 462, AP Assessment q 11
			Illustrative Examples: • Vacuoles	Chapter 4; Chapter 7	70-71; 110-111	**2.D.a:** Represent relationships within biological models, including mathematical models	Chapter 28, p. 529, Check Your Progress, q. 4
			• Cilia	Chapter 21; Chapter 28	(373 – in protists, 512-513, 510-520 – in molluscs, flatworms, and rotifers		
			• Stomata	Chapter 25	457-458		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
2.4: Plasma Membranes	**ENE-2:** Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.	**ENE-2.A:** Describe the roles of each of the components of the cell membrane in maintaining the internal environment of the cell.	**ENE-2.A.1:** Phospholipids have both hydrophilic and hydrophobic regions. The hydrophilic phosphate regions of the phospholipids are oriented toward the aqueous external or internal environments, while the hydrophobic fatty acid regions face each other within the interior of the membrane.	Chapter 3; Chapter 5	44-45; 80-81	**2.A:** Describe relationships between components of a visual representation (of a concept, process, or model).	Chapter 5, p. 84, Check Your Progress, q. 1
			ENE-2.A.2: Embedded proteins can be hydrophilic, with charged and polar side groups, or hydrophobic, with nonpolar side groups.	Chapter 5	80-81		
		ENE-2.B: Describe the Fluid Mosaic Model of cell membranes.	**ENE-2.B.1:** Cell membranes consist of a structural framework of phospholipid molecules that is embedded with proteins, steroids (such as cholesterol in eukaryotes), glycoproteins, and glycolipids that can flow around the surface of the cell within the membrane.	Chapter 5	80-84	**2.A:** Describe relationships between components of a visual representation (of a concept, process, or model).	Chapter 5, p. 84, Check Your Progress, q. 2
2.5: Membrane Permeability	**ENE-2:** Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.	**ENE-2.C:** Explain how the structure of biological membranes influences selective permeability.	**ENE-2.C.1:** The structure of cell membranes results in selective permeability.	Chapter 5	84, 89-91	**3.D:** Make observations or collect data from representations of laboratory setups or results.	Chapter 5, p. 95, AP Assessment, q. 4
			ENE-2.C.2: Cell membranes separate the internal environment of the cell from the external environment.	Chapter 5	80		
			ENE-2.C.3: Selective permeability is a direct consequence of membrane structure, as described by the Fluid Mosaic Model.	Chapter 5	80-84		
			ENE-2.C.4: Small nonpolar molecules, including N_2, O_2, and CO_2 freely pass across the membrane. Hydrophilic substances, such as large polar molecules and ions, move across the membrane through embedded channel and transport proteins.	Chapter 5	84-91		
			ENE-2.C.5: Polar uncharged molecules, including H_2O, pass through the membrane in small amounts.	Chapter 5	84		
		ENE-2.D: Describe the role of the cell wall in maintaining cell structure and function.	**ENE-2.D.1:** Cell walls provide a structural boundary, as well as a permeability barrier for some substances to the internal environments.	Chapter 4; Chapter 5	60, 64-65; 93	**3.D:** Make observations or collect data from representations of laboratory setups or results.	Chapter 22, p. 400, AP Assessment, q. 2
			ENE-2.D.2: Cell walls of plants, prokaryotes, and fungi are composed of complex carbohydrates.	Chapter 4; Chapter 5; Chapter 22	60, 64-65; 93; 387-388		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
2.6: Membrane Transport	**ENE-2:** Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.	**ENE-2.E:** Describe the mechanisms that organisms use to maintain solute and water balance.	**ENE-2.E.1:** Passive transport is the net movement of molecules from high concentration to low concentration without the direct input of metabolic energy.	Chapter 5	85-88	**3.E.b:** Propose a new/next investigation based on an evaluation of the design/methods.	Chapter 5, p. 95, AP Assessment, q. 3, 4,
			ENE-2.E.2: Passive transport plays a primary role in the import of materials and the export of wastes.	Chapter 5	85-86		
			ENE-2.E.3: Active transport requires the direct input of energy to move molecules from regions of low concentration to regions of high concentration.	Chapter 5	88-91		
		ENE-2.F: Describe the mechanisms that organisms use to transport large molecules across the plasma membrane.	**ENE-2.F.1:** The selective permeability of membranes allows for the formation of concentration gradients of solutes across the membrane.	Chapter 5	84	**3.E.b:** Propose a new/next investigation based on an evaluation of the design/methods.	Chapter 5, p. 95, AP Assessment, q. 11
			ENE-2.F.2: The processes of endocytosis and exocytosis require energy to move large molecules into and out of cells–	Chapter 5	89-91		
			a. In exocytosis, internal vesicles fuse with the plasma membrane and secrete large macromolecules out of the cell.	Chapter 5	89-90		
			b. In endocytosis, the cell takes in macromolecules and particulate matter by forming new vesicles derived from the plasma membrane.	Chapter 5	89-91		
2.7: Facilitated Diffusion	**ENE-2:** Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.	**ENE-2.G:** Explain how the structure of a molecule affects its ability to pass through the plasma membrane.	**ENE-2.G.1:** Membrane proteins are required for facilitated diffusion of charged and large polar molecules through a membrane–	Chapter 5	88	**6.E.b:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	Chapter 5, p. 95, AP Assessment, q. 11b
			a. Large quantities of water pass through aquaporins.	Chapter 5	84		
			b. Charged ions, including Na^+ and K^+, require channel proteins to move through the membrane.	Chapter 5	82-84		
			c. Membranes may become polarized by movement of ions across the membrane.	Chapter 5	88-90		
			ENE-2.G.2: Membrane proteins are necessary for active transport.	Chapter 5	88-91		
			ENE-2.G.3: Metabolic energy (such as from ATP) is required for active transport of molecules and/or ions across the membrane and to establish and maintain concentration gradients.	Chapter 5	88-90		
			ENE-2.G.4: The Na+/K+ ATPase contributes to the maintenance of the membrane potential.	Chapter 5	88-90		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
2.8: Tonicity and Osmoregulation	**ENE-2:** Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.	**ENE-2.H:** Explain how concentration gradients affect the movement of molecules across membranes.	**ENE-2.H.1:** External environments can be hypotonic, hypertonic, or isotonic to internal environments of cells– a. Water moves by osmosis from areas of high-water potential/low osmolarity/low solute concentration to areas of low water potential/high osmolarity/high solute concentration Relevant Equation Water Potential: $\Psi = \Psi_p + \Psi_s$ Ψ_p = pressure potential Ψ_s = solute potential	Chapter 5; Chapter 25	87-88; 449-461	**4.A:** Construct a graph, plot, or chart.	
		ENE-2.I: Explain how osmoregulatory mechanisms contribute to the health and survival of organisms.	**ENE-2.I.1:** Growth and homeostasis are maintained by the constant movement of molecules across membranes.	Chapter 5; Chapter 25; Chapter 36	85-93; 449-460	**4.A:** Construct a graph, plot, or chart.	Chapter 36, p. 668, AP Assessment q. 9
			ENE-2.I.2: Osmoregulation maintains water balance and allows organisms to control their internal solute composition/water potential. **SOLUTE POTENTIAL OF A SOLUTION** $\Psi_s = -iCRT$ where: i = ionization constant C = molar concentration R = pressure constant $\left(R = 0.0831 \frac{L \bullet bars}{mol \bullet K}\right)$ T = temperature in Kelvin ($°C + 273$)	Chapter 5; Chapter 25; Chapter 36	87-88; 453-458; 657-660		
			Illustrative Examples: • Contractile vacuole in protists	Chapter 21	369-370, 381		
			• Central vacuoles in plant cells.	Chapter 25	455		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
2.9: Mechanisms of Transport	**ENE-2:** Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.	**ENE-2.J:** Describe the processes that allow ions and other molecules to move across membranes.	**ENE-2.J.1:** A variety of processes allow for the movement of ions and other molecules across membranes, including passive and active transport, endocytosis and exocytosis.	Chapter 5	82-92	**1.B:** Explain biological concepts and/or processes.	Chapter 5, p. 91, Check Your Progress, q. 1
2.10: Cell Compartmentalization	**ENE-2:** Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.	**ENE-2.K:** Describe the membrane-bound structures of the eukaryotic cell.	**ENE-2.K.1:** Membranes and membrane-bound organelles in eukaryotic cells compartmentalize intracellular metabolic processes and specific enzymatic reactions.	Chapter 4	62-76	**6.E.a:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on biological concepts or processes.	Chapter 4, p. 78, AP Assessment, q. 7
		ENE-2.L: Explain how internal membranes and membrane-bound organelles contribute to compartmentalization of eukaryotic cell functions.	**ENE-2.L.1:** Internal membranes facilitate cellular processes by minimizing competing interactions and by increasing surface areas where reactions can occur.	Chapter 4	61, 64-72		Chapter 4, p. 77, AP Assessment, q. 4
2.11: Origins of Cell Compartmentalization	**EVO-1:** Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.	**EVO-1.A:** Describe similarities and/or differences in compartmentalization between prokaryotic and eukaryotic cells.	**EVO-1.A.1:** Membrane-bound organelles evolved from once free-living prokaryotic cells via endosymbiosis.	Chapter 4; Chapter 18; Chapter 21	62; 319-321; 367	**6.B: S**upport a claim with evidence from biological principles, concepts, processes, and/or data	Chapter 4, p. 73, Check Your Progress 4.7, q. 2; Chapter 21, p. 384, q 11
			EVO-1.A.2: Prokaryotes generally lack internal membrane-bound organelles but have internal regions with specialized structures and functions.	Chapter 4; Chapter 20	60; 350-357		
			EVO-1.A.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.	Chapter 4	60, 62-65		
		EVO-1.B: Describe the relationship between the functions of endosymbiotic organelles and their free-living ancestral counterparts.	**EVO-1.B.1:** Membrane-bound organelles evolved from previously free-living prokaryotic cells via endosymbiosis.	Chapter 4; Chapter 18; Chapter 21	62; 319-321; 367		Chapter 4, p. 73, Check Your Progress 4.7, q. 2; Chapter 21, p. 384, q 11

Unit 3: Cellular Energetics
12-16%

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
3.1: Enzyme Structure	**ENE-1:** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.	**ENE-1.D:** Describe the properties of enzymes.	**ENE-1.D.1:** The structure of enzymes includes the active site that specifically interacts with substrate molecules.	Chapter 6	101-103	**1.B:** Explain biological concepts and/or processes.	Chapter 6, p. 105, Check Your Progress, q. 2, 3
			ENE-1.D.2: For an enzyme-mediated chemical reaction to occur, the shape and charge of the substrate must be compatible with the active site of the enzyme.	Chapter 6	103-105		
3.2: Enzyme Catalysis	**ENE-1:** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.	**ENE-1.E:** Explain how enzymes affect the rate of biological reactions.	**ENE-1.E.1:** The structure and function of enzymes contribute to the regulation of biological processes– **a.** Enzymes are biological catalysts that facilitate chemical reactions in cells by lowering the activation energy.	Chapter 6	101-103	**3.C.c:** Identify experimental procedures that are aligned to the question, including justifying appropriate controls.	Chapter 6, p. 108, AP Assessment, q. 10
						3.C.b: Identify experimental procedures that are aligned to the question, including identifying appropriate controls.	Chapter 6, p. 108 AP Assessment, q. 9
3.3: Environmental Impacts on Enzyme Function	**ENE-1:** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.	**ENE-1.F:** Explain how changes to the structure of an enzyme may affect its function.	**ENE-1.F.1:** Change to the molecular structure of a component in an enzymatic system may result in a change of the function or efficiency of the system–	Chapter 6	102-105	**6.E.c:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on data.	Chapter 6, p. 108, AP Assessment, q. 10
			a. Denaturation of an enzyme occurs when the protein structure is disrupted, eliminating the ability to catalyze reactions.	Chapter 6	103		
			b. Environmental temperatures and pH outside the optimal range for a given enzyme will cause changes to its structure, altering the efficiency with which it catalyzes reactions.	Chapter 6	103-105		
			ENE-1.F.2: In some cases, enzyme denaturation is reversible, allowing the enzyme to regain activity.	Chapter 6	104		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
		ENE-1.G: Explain how the cellular environment affects enzyme activity.	**ENE-1.G.1:** Environmental pH can alter the efficiency of enzyme activity, including through disruption of hydrogen bonds that provide enzyme structure. Relevant Equation – $pH = -\log[H^+]$ *Exclusion Statement--Students must understand the underlying concepts and applications of this equations, but performing calculations using this equation is beyond the scope of the course and the AP Exam.*	Chapter 6	102-103	**6.E.c:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on data.	Chapter 6, p. 108, AP Assessment, q. 6
			ENE-1.G.2: The relative concentrations of substrates and products determine how efficiently an enzymatic reaction proceeds.	Chapter 6	102		
			ENE-1.G.3: Higher environmental temperatures increase the speed of movement of molecules in a solution, increasing the frequency of collisions between enzymes and substrates and therefore increasing the rate of reaction.	Chapter 6	103		
			ENE-1.G.4: Competitive inhibitor molecules can bind reversibly or irreversibly to the active site of the enzyme. Noncompetitive inhibitors can bind allosteric sites, changing the activity of the enzyme.	Chapter 6	104		
3.4: Cellular Energy	**ENE-1:** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.	**ENE-1.H:** Describe the role of energy in living organisms	**ENE-1.H.1:** All living systems require constant input of energy.	Chapter 6	97-98	**6.C:** Provide reasoning to justify a claim by connecting evidence to biological theories.	Chapter 6, p. 98, Check Your Progress, q. 1,2
			ENE-1.H.2: Life requires a highly ordered system and does not violate the second law of thermodynamics– **a.** Energy input must exceed energy loss to maintain order and to power cellular processes.	Chapter 6	97-98		
			b. Cellular processes that release energy may be coupled with cellular processes that require energy.	Chapter 6	99-101		
			c. Loss of order or energy flow results in death. *Exclusion Statement--Students will need to understand the concept of energy, but the equation for Gibbs free energy is beyond the scope of the course and the AP Exam.*	Chapter 6	104-105		
			ENE-1.H.3: Energy-related pathways in biological systems are sequential to allow for a more controlled and efficient transfer of energy. A product of a reaction in a metabolic pathway is generally the reactant for the subsequent step in the pathway.	Chapter 6	101-107		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
3.5: Photosynthesis	**ENE-1:** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.	**ENE-1.I:** Describe the photosynthetic processes that allow organisms to capture and store energy.	**ENE-1.I.1:** Organisms capture and store energy for use in biological processes–	Chapter 4; Chapter 6; Chapter 7	71-72; 97-98, 104-107; 110-111	**6.B:** Support a claim with evidence from biological principles, concepts, processes, and/or data.	Chapter 7, p. 123, AP Assessment, q. 7, 8, 9
			a. Photosynthesis captures energy from the sun and produces sugars– **i.** Photosynthesis first evolved in prokaryotic organisms. **ii.** Scientific evidence supports the claim that prokaryotic (cyanobacterial) photosynthesis was responsible for the production of an oxygenated atmosphere. **iii.** Prokaryotic photosynthetic pathways were the foundation of eukaryotic photosynthesis.	Chapter 6; Chapter 7; Chapter 18; Chapter 20	106; 110-122; 318, 320; 360-362		
			ENE-1.I.2: The light-dependent 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.	Chapter 7; Chapter 8	114-122; 136-137		
		ENE-1.J: Explain how cells capture energy from light and transfer it to biological molecules for storage and use.	**ENE-1.J.1:** During photosynthesis, chlorophylls absorb energy from light, boosting electrons to a higher energy level in photosystems I and II.	Chapter 7	110-113, 114-118	**6.B:** Support a claim with evidence from biological principles, concepts, processes, and/or data.	Chapter 7, p. 123, AP Assessment Response, q. 8
			ENE-1.J.2: Photosystems I and II are embedded in the internal membranes of chloroplasts and are connected by the transfer of higher energy electrons through an electron transport chain (ETC).	Chapter 7	114-118		
			ENE-1.J.3: When electrons are transferred between molecules in a sequence of reactions as they pass through the ETC, an electrochemical gradient of protons (hydrogen ions) is established across the internal membrane.	Chapter 7	117-118		
			ENE-1.J.4: The formation of the proton gradient is linked to the synthesis of ATP from ADP and inorganic phosphate via ATP synthase.	Chapter 7	114-118		
			ENE-1.J.5: 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, which occurs in the stroma of the chloroplast. *Exclusion Statement--Memorization of the steps in the Calvin cycle, the structure of the molecules and the names of enzymes (with the exception of ATP synthase) are beyond the scope of the course and the AP Exam.*	Chapter 7	110-113, 118-120		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
3.6: Cellular Respiration	**ENE-1:** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.	**ENE-1.K:** Describe the processes that allow organisms to use energy stored in biological macromolecules.	**ENE-1.K.1:** Fermentation and cellular respiration use energy from biological macromolecules to produce ATP. Respiration and fermentation are characteristic of all forms of life.	Chapter 6; Chapter 8	106-107; 124-127	**4.A:** Construct a graph, plot, or chart.	Chapter 8, p. 139, AP Assessment q. 7
			ENE-1.K.2: Cellular respiration in eukaryotes involves a series of coordinated enzyme-catalyzed reactions that capture energy from biological macromolecules.	Chapter 6; Chapter 8	106-107; 125-137		
			ENE-1.K.3: The electron transport chain transfers energy from electrons in a series of coupled reactions that establish an electrochemical gradient across membranes– **a.** Electron transport chain reactions occur in chloroplasts, mitochondria, and prokaryotic plasma membranes.	Chapter 7; Chapter 8	112-118; 127-137		
			b. 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. In photosynthesis, the terminal electron acceptor is $NADP^+$. Aerobic prokaryotes use oxygen as a terminal electron acceptor, while anaerobic prokaryotes use other molecules.	Chapter 7; Chapter 8	112-113, 116-118; 127-137		
			c. The transfer of electrons is accompanied by the formation of a proton gradient across the inner mitochondrial membrane or the internal membrane of chloroplasts, with the membrane(s) separating a region of high proton concentration from a region of low proton concentration. In prokaryotes, the passage of electrons is accompanied by the movement of protons across the plasma membrane.	Chapter 7; Chapter 8	111-116; 127-137		
			d. 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 cellular respiration, and photophosphorylation in photosynthesis.	Chapter 7; Chapter 8	116-118; 127-131		
			e. In cellular respiration, decoupling oxidative phosphorylation from electron transport generates heat. This heat can be used by endothermic organisms to regulate body temperature. *Exclusion Statement--The names of the specific electron carriers in the electron transport chain are beyond the scope of the course and the AP Exam.*	Chapter 8	125, 135		
		ENE-1.L: Explain how cells obtain energy from biological macromolecules in order to power cellular functions	**ENE-1.L.1:** Glycolysis is a biochemical pathway that releases the energy in glucose to form ATP from ADP and inorganic phosphate, NADH from NAD+, and pyruvate.	Chapter 8	126-129	**4.A:** Construct a graph, plot, or chart.	Chapter 8, p. 139, AP Assessment q. 7
			ENE-1.L.2: Pyruvate is transported from the cytosol to the mitochondrion, where further oxidation occurs.	Chapter 8	126-129, 131-132		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
		ENE-1.L: Explain how cells obtain energy from biological macromolecules in order to power cellular functions	**ENE-1.L.3:** In the Krebs cycle, carbon dioxide is released from organic intermediates, ATP is synthesized from ADP and inorganic phosphate, and electrons are transferred to the coenzymes NADH and $FADH_2$.	Chapter 8	132-135	**4.A:** Construct a graph, plot, or chart.	Chapter 8, p. 139, AP Assessment q. 7
			ENE-1.L.4: Electrons extracted in glycolysis and Krebs cycle reactions are transferred by NADH and $FADH_2$ to the electron transport chain in the inner mitochondrial membrane.	Chapter 8	125-137		
			ENE-1.L.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.	Chapter 8	126, 133-134, 137		
			ENE-1.L.6: Fermentation allows glycolysis to proceed in the absence of oxygen and produces organic molecules, including alcohol and lactic acid, as waste products.	Chapter 8	129-134		
			ENE-1.L.7: The conversion of ATP to ADP releases energy, which is used to power many metabolic processes. *Exclusion Statement--Memorization of the steps in glycolysis and the Krebs cycle, and of the structures of the molecules and the names of the enzymes involved, are beyond the scope of the course and the AP Exam.*	Chapter 4; Chapter 5; Chapter 6; Chapter 7; Chapter 8	71; 88-90; 99-100; 112; 125, 127-129, 133-137		
3.7: Fitness	**SYI-3:** Naturally occurring diversity among and between components within biological systems affects interactions with the environment.	**SYI-3.A:** Explain the connection between variation in the number and types of molecules within cells to the ability of the organism to survive and/or reproduce in different environments.	**SYI-3.A.1:** Variation at the molecular level provides organisms with the ability to respond to a variety of environmental stimuli.	Chapter 3; Chapter 26; Chapter 32; Chapter 33; Chapter 37; Chapter 40; Chapter 43	39-48; 465-472; 596-598; 608-613; 671-673; 728; 795-798	**6.C:** Provide reasoning to justify a claim by connecting evidence to biological theories.	Chapter 37, p. 690, AP Assessment q. 11
			SYI-3.A.2: Variation in the number and types of molecules within cells provides organisms a greater ability to survive and/or reproduce in different environments.	Chapter 5; Chapter 7; Chapter 26; Chapter 27; Chapter 33; Chapter 37; Chapter 40	82-83; 114; 465-80; 487-489; 608-613; 671-675, 680; 728		
			Illustrative Example • Different types of phospholipids in cell membranes allow the organism flexibility to adapt to different environmental temperatures.	Chapter 3	42-45		
			• Different types of hemoglobin maximize oxygen absorption in organisms at different developmental stages.	Chapter 32	596-597, 600		
			• Different chlorophylls give the plant greater flexibility to exploit/ absorb incoming wavelengths of light for photosynthesis.	Chapter 7	114		

Unit 4: Cell Communication and Cell Cycle
10-15%

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
4.1: Cell Communication	**IST-3:** Cells communicate by generating, transmitting, receiving, and responding to chemical signals.	**IST-3.A:** Describe the ways that cells can communicate with one another.	**IST-3.A.1:** Cells communicate with one another through direct contact with other cells or from a distance via chemical signaling– **a.** Cells communicate by cell-to-cell contact.	Chapter 5	82-84, 91-93	1.B: Explain biological concepts and/or processes.	Chapter 5, p. 95, AP Assessment, q. 6, 7, 10, 11
			Illustrative Examples: · Immune cells interact by cell-to-cell contact, antigen-presenting cells (APCs), helper T-cells, and killer T-cells.	Chapter 33	609-10, 611-12		
			· Plasmodesmata between plant cells allow material to be transported from cell to cell.	Chapter 5	93		
		IST-3.B: Explain how cells communicate with one another over short and long distances.	**IST-3.B.1:** Cells communicate over short distances by using local regulators that target cells in the vicinity of the signal-emitting cell–	Chapter 5; Chapter 9; Chapter 26; Chapter 37; Chapter 42	83; 143-144; 465-473; 674-676; 771-773	1.B: Explain biological concepts and/or processes.	Chapter 41, p. 764, Accessing the Big Ideas, Free Response, q. 8
			Illustrative Examples: · Neurotransmitters	Chapter 37	675-676		
			· Plant immune response	Chapter 26	472-473		
			· Quorum sensing in bacteria				
			· Morphogens in embryonic development	Chapter 42	771		
			a. Signals released by one cell type can travel long distances to target cells of another cell type.	Chapter 5; Chapter 26; Chapter 33; Chapter 38; Chapter 41; Chapter 42	83; 466-473; 607-619; 692-694; 750, 753-754; 778-784		
			Illustrative Examples: · Insulin	Chapter 40	737-739		
			· Human growth hormone	Chapter 40	732		
			· Thyroid hormones	Chapter 40	731-734		
			· Testosterone	Chapter 40; Chapter 41	739-740; 750		
			· Estrogen	Chapter 40; Chapter 41	739-740; 753		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
4.2: Introduction to Signal Transduction	**IST-3:** Cells communicate by generating, transmitting, receiving, and responding to chemical signals.	**IST-3.C:** Describe the components of a signal transduction pathway.	**IST-3.C.1:** Signal transduction pathways link signal reception with cellular responses.	Chapter 5; Chapter 26	83; 465-466	1.B: Explain biological concepts and/or processes.	Chapter 40, p. 742, AP Assessment, q. 5, 6, 7
			IST-3.C.2: Many signal transduction pathways include protein modification and phosphorylation cascades.	Chapter 5; Chapter 8; Chapter 9; Chapter 26; Chapter 33; Chapter 38	83; 127-131; 144; 465-475; 607-619; 698		
		IST-3.D: Describe the role of components of a signal transduction pathway in producing a cellular response.	**IST-3.D.1:** Signaling begins with the recognition of a chemical messenger—a ligand—by a receptor protein in a target cell–	Chapter 5; Chapter 6; Chapter 13; Chapter 40	82; 101; 220, 227; 728-729		Chapter 5, p. 95, AP Assessment, q. 9, 11
			a. The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide, a small chemical, or protein, in a specific one-to-one relationship.	Chapter 5; Chapter 6; Chapter 13	82; 101; 220, 227		
			b. G protein-coupled receptors are an example of a receptor protein in eukaryotes.	Chapter 5; Chapter 6; Chapter 13	82; 101; 220, 227		
			IST-3.D.2: Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, resulting in the appropriate responses by the cell, which could include cell growth, secretion of molecules, or gene expression–	Chapter 5; Chapter 6; Chapter 13; Chapter 40	83; 101; 220-223, 227; 728		
			a. After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal.	Chapter 6; Chapter 13	104; 220-223, 227		
			b. Second messengers (such as cyclic AMP) are molecules that relay and amplify the intracellular signal.	Chapter 13; Chapter 40	220-223, 227; 728-729		
			c. Binding of ligand-to-ligand-gated channels can cause the channel to open or close.	Chapter 8; Chapter 37	133-34; 674-675		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
4.3: Signal Transduction	**IST-3:** Cells communicate by generating, transmitting, receiving, and responding to chemical signals.	**IST-3.E:** Describe the role of the environment in eliciting a cellular response.	**IST-3.E.1:** Signal transduction pathways influence how the cell responds to its environment.	Chapter 5; Chapter 6; Chapter 13; Chapter 33; Chapter 40; Chapter 42	83; 101; 220-222, 227; 617 728-729; 773-775	**6C:** Provide reasoning to justify a claim by connecting evidence to biological theories.	Chapter 13, p. 235, AP Assessment, q. 6; Chapter 40, p. 742, AP Assessment, q. 7
			Illustrative Examples: · Use of chemical messengers by microbes to communicate with other nearby cells and to regulate specific pathways in response to population density (quorum sensing). · Epinephrine stimulation of glycogen breakdown in mammals.	Chapter 40	728-729		
		IST-3.F: Describe the different types of cellular responses elicited by a signal transduction pathway.	**IST-3.F.1:** Signal transduction may result in changes in gene expression and cell function, which may alter phenotype or result in programmed cell death (apoptosis).	Chapter 9; Chapter 13; Chapter 26; Chapter 28; Chapter 33; Chapter 40	143-144; 220-231; 465-473; 506-507; 617-619; 728-729		Chapter 26, p. 481, AP Assessment, q. 7
			Illustrative Examples: · Cytokines regulate gene expression to allow for cell replication and division.	Chapter 26	469		
			· Mating pheromones in yeast trigger mating gene expression.	Chapter 22	391		
			· Expression of the *SRY* gene triggers the male sexual development pathway in animals.	Chapter 10	173		
			· Ethylene levels cause changes in the production, of different enzymes allowing fruits to ripen.	Chapter 26	471-472		
			· HOX genes and their role in development.	Chapter 28	506-507		
4.4: Changes in Signal Transduction Pathways	**IST-3:** Cells communicate by generating, transmitting, receiving, and responding to chemical signals.	**IST-3.G:** Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway.	**IST-3.G.1:** Changes in signal transduction pathways can alter cellular response–	Chapter 6; Chapter 9; Chapter 11; Chapter 13; Chapter 14; Chapter 16; Chapter 31; Chapter 47	103-105; 143-155; 187-190; 220, 232-234; 240-246; 277-278; 579-580; 888	**6.E.b:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	Chapter 9, p. 155, Check Your Progress, q. 3
			a. 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.	Chapter 6; Chapter 9; Chapter 11; Chapter 13; Chapter 35; Chapter 43	103; 143-155; 187-190; 232-234; 653; 790		
			IST-3.G.2: Chemicals that interfere with any component of the signaling pathway may activate or inhibit the pathway.	Chapter 8; Chapter 16; Chapter 37; Chapter 42; Chapter 47	133; 277; 671-672, 677-678; 781; 888		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
4.5: Feedback	**ENE-3:** Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.	**ENE-3.A:** Describe positive and/or negative feedback mechanisms.	**ENE-3.A.1:** Organisms use feedback mechanisms to maintain their internal environments and respond to internal and external environmental changes.	Chapter 31	579-581	**6.E.b:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	Chapter 31, p. 581, Check Your Progress, q. 3
		ENE-3.B: Explain how negative feedback helps to maintain homeostasis.	**ENE-3.B.1:** Negative feedback mechanisms maintain homeostasis for a particular condition by regulating physiological processes. If a system is perturbed, negative feedback mechanisms return the system back to its target set point. These processes operate at the molecular and cellular levels.	Chapter 31; Chapter 40	579-580; 732		Chapter 40, p. 742, AP Assessment, q. 7
			Illustrative Examples: · Blood sugar regulation by insulin/glucagon.	Chapter 40	738		
		ENE-3.C: Explain how positive feedback affects homeostasis.	**ENE-3.C.1:** Positive feedback mechanisms amplify responses and processes in biological organisms. The variable initiating the response is moved farther away from the initial set point. Amplification occurs when the stimulus is further activated which, in turn, initiates an additional response that produces system change.	Chapter 31; Chapter 40	581; 730-731		
			Illustrative Examples: · Lactation in mammals.	Chapter 40	730-731		
			· Onset of labor in childbirth.	Chapter 40	730-731		
			· Ripening of fruit.	Chapter 26	470-472		
4.6: Cell Cycle	**IST-1:** Heritable information provides for continuity of life.	**IST-1.B:** Describe the events that occur in the cell cycle.	**IST-1.B.1:** In eukaryotes, cells divide and transmit genetic information via two highly regulated processes.	Chapter 9	142-143, 145-148	**4.B.b:** Describe data from a table or graph, including describing trends and/or patterns in the data.	Chapter 9, p. 158, AP Assessment, q. 1
			IST-1.B.2: The cell cycle is a highly regulated series of events for the growth and reproduction of cells–	Chapter 9	142-143		
			a. The cell cycle consists of sequential stages of interphase (G1, S, G2), mitosis and cytokinesis.	Chapter 9	142-143		
			b. A cell can enter a stage (G0) where it no longer divides, but it can reenter the cell cycle in response to appropriate cues. Nondividing cells may exit the cell cycle or be held at a particular stage in the cell cycle.	Chapter 9	142-143		
		IST-1.C: Explain how mitosis results in the transmission of chromosomes from one generation to the next.	**IST-1.C.1:** Mitosis is a process that ensures the transfer of a complete genome from a parent cell to two genetically identical daughter cells–	Chapter 9	146-152	**5.A.e:** Perform mathematical calculations, including percentages	
			a. Mitosis plays a role in growth, tissue repair, and asexual reproduction.	Chapter 9	146-152		
			b. Mitosis alternates with interphase in the cell cycle.	Chapter 9	146-152		
			c. Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase).	Chapter 9	146-152		

Topic Name # of Class Periods	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
4.7: Regulation of Cell Cycle	**IST-1:** Heritable information provides for continuity of life.	**IST-1.D:** Describe the role of checkpoints in regulating the cell cycle.	**IST-1.D.1:** A number of internal controls or checkpoints regulate progression through the cycle.	Chapter 9	143-144, 152-155	**6.E.b:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	Chapter 9, p. 144, Question to Consider, q. 1
			IST-1.D.2: Interactions between cyclins and cyclin-dependent kinases control the cell cycle. *Exclusion Statement--Knowledge of specific cyclin-CdK pairs or growth factors is beyond the scope of the course and the AP Exam.*	Chapter 9	143-144, 152-155		
		IST-1.E: Describe the effects of disruptions to the cell cycle on the cell or organism.	**IST-1.E.1:** Disruptions to the cell cycle may result in cancer and/or programmed cell death (apoptosis).	Chapter 9	143-144, 152-155		Chapter 9, p. 155, Check Your Progress, q. 3

Unit 5: Heredity
8-11%

Topic Name # of Class Periods	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
5.1: Meiosis	**IST-1:** Heritable information provides for continuity of life.	**IST-1.F:** Explain how meiosis results in the transmission of chromosomes from one generation to the next.	**IST-1.F.1:** Meiosis is a process that ensures the formation of haploid gamete cells in sexually reproducing diploid organisms–	Chapter 10	161-163	**1.B:** Explain biological concepts and/or processes.	Chapter 10, p. 178, AP Assessment, q. 11
			a. Meiosis results in daughter cells with half the number of chromosomes of the parent cell.	Chapter 10	161-163		
			b. Meiosis involves two rounds of a sequential series of steps (meiosis I and meiosis II).	Chapter 10	161-163, 165-169		
		IST-1.G: Describe similarities and/or differences between the phases and outcomes of mitosis and meiosis.	**IST-1.G.1:** Mitosis and meiosis are similar in the way chromosomes segregate but differ in the number of cells produced and the genetic content of the daughter cells.	Chapter 10	167-169		Chapter 10, p. 169, Check Your Progress, q. 1, 2
5.2: Meiosis and Genetic Diversity	**IST-1:** Heritable information provides for continuity of life.	**IST-1.H:** Explain how the process of meiosis generates genetic diversity.	**IST-1.H.1:** Separation of the homologous chromosomes in meiosis I ensures that each gamete receives a haploid (1*n*) set of chromosomes that comprises both maternal and paternal chromosomes.	Chapter 10	165-166	**3.A:** Identify or pose a testable question based on an observation, on data, or on a model.	Chapter 10, p. 178, AP Assessment, q. 13
			IST-1.H.2: During meiosis I, homologous chromatids exchange genetic material via a process called crossing over (recombination), which increases genetic diversity among the resultant gametes.	Chapter 10	165-166		
			IST-1.H.3: Sexual reproduction in eukaryotes involving gamete formation—including crossing over, the random assortment of chromosomes during meiosis, and subsequent fertilization of gametes—serves to increase variation. *Exclusion Statement--The details of sexual reproduction cycles in various plants and animals are beyond the scope of the course and the AP Exam.*	Chapter 10	163-165		
5.3: Mendelian Genetics	**EVO-2:** Organisms are linked by lines of descent from common ancestry.	**EVO-2.A:** Explain how shared, conserved, fundamental processes and features support the concept of common ancestry for all organisms.	**EVO-2.A.1:** DNA and RNA are carriers of genetic information.	Chapter 4; Chapter 6; Chapter 12	70-76, 78; 106; 201-202, 208-209	**6.E.c:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on data.	Chapter 12, p. 218, AP Assessment, q. 5
			EVO-2.A.2: Ribosomes are found in all forms of life.	Chapter 4	56-76		
			EVO-2.A.3: Major features of the genetic code are shared by all modern living systems.	Chapter 12	208-209		
			EVO-2.A.4: Core metabolic pathways are conserved across all currently recognized domains.	Chapter 6	106		

Topic Name # of Class Periods	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
	IST-1: Heritable information provides for continuity of life.	**IST-1.I:** Explain the inheritance of genes and traits as described by Mendel's laws.	**IST-1.I.1:** Mendel's laws of segregation and independent assortment can be applied to genes that are on different chromosomes.	Chapter 10; Chapter 11	167; 184-187	**5.C:** Perform chi-square hypothesis testing.	Chapter 11, p. 199, AP Assessment q. 2, 3
			IST-1.I.2: 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–	Chapter 10	165, 169-171		
			a. Rules of probability can be applied to analyze passage of single-gene traits from parent to offspring.	Chapter 11	181-190		
			b. The pattern of inheritance (monohybrid, dihybrid, sex-linked, and genetically linked genes) can often be predicted from data, including pedigree, that give the parent genotype/phenotype and the offspring genotypes/phenotypes. RELEVANT EQUATION 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: $P(A \text{ and } B) = P(A) \times P(B)$	Chapter 11	181-190		
5.4: Non-Mendelian Genetics	**IST-1:** Heritable information provides for continuity of life.	**IST-1.J:** Explain deviations from Mendel's model of the inheritance of traits.	**IST-1.J.1:** Patterns of inheritance of many traits do not follow ratios predicted by Mendel's laws and can be identified by quantitative analysis, where observed phenotypic ratios statistically differ from the predicted ratios–	Chapter 10; Chapter 11	171-176; 190-198	**5.C:** Perform chi-square hypothesis testing.	Chapter 11, Chapter Resources Activities (online)
			a. Genes that are adjacent and close to one another on the same chromosome may appear to be genetically linked; the probability that genetically linked genes will segregate as a unit can be used to calculate the map distance between them.	Chapter 14	247-252	**5.A.b:** Perform mathematical calculations, including means.	Chapter 11, Chapter Resources Activities (online)
			IST-1.J.2: Some traits are determined by genes on sex chromosomes, and are known as sex-linked traits. The pattern of inheritance of sex-linked traits can often be predicted from data, including pedigree, indicating the parent genotype/phenotype and the offspring genotypes/phenotypes.	Chapter 11	195-198		
			Illustrative Examples: · Sex-linked genes reside on sex chromosomes.	Chapter 11	195-196		
			· In mammals and flies, females are XX and males are XY; as such, X-linked recessive traits are always expressed in males.	Chapter 11	195-196		
			· In certain species, the chromosomal basis of sex determination is not based on X and Y chromosomes (such as ZW in birds, haplodiploidy in bees).	Chapter 28	502		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
			IST-1.J.3: Many traits are the product of multiple genes and/or physiological processes acting in combination; these traits therefore do not segregate in Mendelian patterns.	Chapter 11; Chapter 16	193-194; 280	**5.A.b:** Perform mathematical calculations, including means.	Chapter 11, p. 199, AP Assessment q. 2, 3
			IST-1.J.4: Some traits result from non-nuclear inheritance– **a.** 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. **b.** In animals, mitochondria are transmitted by the egg and not by sperm; as such, traits determined by the mitochondrial DNA are maternally inherited. **c.** In plants, mitochondria and chloroplasts are transmitted in the ovule and not in the pollen; as such, mitochondria-determined and chloroplast-determined traits are maternally inherited.	Chapter 4	73		Chapter 4, p. 73, Check Your Progress, q. 1-2
5.5: Environmental Effects on Phenotype	**SYI-3:** Naturally occurring diversity among and between components within biological systems affects interactions with the environment.	**SYI-3.B:** Explain how the same genotype can result in multiple phenotypes under different environmental conditions.	**SYI-3.B.1:** Environmental factors influence gene expression and can lead to phenotypic plasticity. Phenotypic plasticity occurs when individuals with the same genotype exhibit different phenotypes in different environments.	Chapter 11; Chapter 16	183-184, 194, 286	**1.C:** Explain biological concepts, processes, and/or models in applied contexts.	Chapter 22, p. 401, AP Assessment, q. 6
			Illustrative Examples: · *Height and weight in humans.* · *Flower color based on soil pH.* · *Seasonal fur color in arctic animals.* · *Sex determination in reptiles.* · *Effect of increased UV on melanin production in animals.* · *Presence of the opposite mating type on pheromone production in yeast and other fungi.*	Chapter 11; Chapter 16; Chapter 22	185; 193-194; 274; 401		
5.6: Chromosomal Inheritance	**SYI-3:** Naturally occurring diversity among and between components within biological systems affects interactions with the environment.	**SYI-3.C:** Explain how chromosomal inheritance generates genetic variation in sexual reproduction.	**SYI-3.C.1:** Segregation, independent assortment of chromosomes, and fertilization result in genetic variation in populations.	Chapter 10; Chapter 11; Chapter 42	163-165; 181-187; 767-768	**6.E.b:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	Chapter 11, p. 199, AP Assessment, q. 7
			SYI-3.C.2: The chromosomal basis of inheritance provides an understanding of the pattern of transmission of genes from parent to offspring.	Chapter 11	187-188		

Topic Name # of Class Periods	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
			SYI-3.C.3: Certain human genetic disorders can be attributed to the inheritance of a single affected or mutated allele or specific chromosomal changes, such as nondisjunction.	Chapter 11	187-190	**6.E.b:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	Chapter 11, p. 199, AP Assessment, q. 7
			Illustrative Examples: · *Sickle cell anemia.*	Chapter 11; Chapter 13	192-193; 233		
			· *Tay-Sachs disease.*	Chapter 4	68-69		
			· *Huntington's disease.*	Chapter 11	190		
			· *X-linked color blindness.*	Chapter 11	196		
			· *Trisomy 21/Down syndrome.*	Chapter 10	173		

Unit 6: Gene Expression and Regulation

12-16%

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
6.1: DNA and RNA Structure	**IST-1:** Heritable information provides for continuity of life.	**IST-1.K:** Describe the structures involved in passing hereditary information from one generation to the next.	**IST-1.K.1:** DNA, and in some cases RNA, is the primary source of heritable information.	Chapter 3; Chapter 12	50-51; 201-209	**1.C:** Explain biological concepts, processes, and/or models in applied contexts	Chapter 12, Check Your Progress 12.3, q. 1; Chapter 12, p. 218, AP Assessment, q. 1, 4
			IST-1.K.2: Genetic information is transmitted from one generation to the next through DNA or RNA–	Chapter 4; Chapter 12	67; 201-217		
			a. Genetic information is stored in and passed to subsequent generations through DNA molecules and, in some cases, RNA molecules.	Chapter 4; Chapter 12	67; 201-203, 206-217		
			b. Prokaryotic organisms typically have circular chromosomes, while eukaryotic organisms typically have multiple linear chromosomes.	Chapter 4; Chapter 20	60, 65-67; 356-357		
			IST-1.K.3: Prokaryotes and eukaryotes can contain plasmids, which are small extra-chromosomal, double-stranded, circular DNA molecules.	Chapter 4; Chapter 14; Chapter 20	60-61; 237-238; 356-357		
		IST-1.L: Describe the characteristics of DNA that allow it to be used as the hereditary material.	**IST-1.L.1:** DNA, and sometimes RNA, exhibits specific nucleotide base pairing that is conserved through evolution: adenine pairs with thymine or uracil (A-T or A-U) and cytosine pairs with guanine (C-G) –	Chapter 12	203-205, 208-212		Chapter 12, p. 218, AP Assessment, q. 3
			a. Purines (G and A) have a double ring structure.	Chapter 12	203-205		
			b. Pyrimidines (C, T and U) have a single ring structure.	Chapter 12	203-205, 208		
6.2: Replication	**IST-1:** Heritable information provides for continuity of life.	**IST-1.M:** Describe the mechanisms by which genetic information is copied for transmission between generations.	**IST-1.M.1:** DNA replication ensures continuity of hereditary information– **a.** DNA is synthesized in the 5' to 3' direction. **b.** Replication is a semiconservative process–that is, one strand of DNA serves as the template for a new strand of complementary DNA. **c.** Helicase unwinds the DNA strands. **d.** Topoisomerase relaxes supercoiling in front of the replication fork. **e.** DNA polymerase requires RNA primers to initiate DNA synthesis. **f.** DNA polymerase synthesizes new strands of DNA continuously on the leading strand and discontinuously on the lagging strand. **g.** Ligase joins the fragments on the lagging strand. *Exclusion Statement--The names of the steps and particular enzymes involved—beyond DNA polymerase, ligase, RNA polymerase, helicase and topoisomerase—are beyond the scope of the course and the AP Exam*	Chapter 12	206-208	**2.B.b:** Explain biological concepts and/or processes represented visually in applied contexts.	Chapter 12, p. 208, Check your Progress, q. 1

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
6.3: Transcription and RNA Processing	**IST-1:** Heritable information provides for continuity of life.	**IST-1.N:** Describe the mechanisms by which genetic information flows from DNA to RNA to protein.	**IST-1.N.1:** The sequence of the RNA bases, together with the structure of the RNA molecule, determines RNA function–	Chapter 12	208-216	**2.B.b:** Explain biological concepts and/or processes represented visually in applied contexts.	Chapter 12, p. 212, Check Your Progress, q. 1, 2, 3
			a. mRNA molecules carry information from DNA to the ribosome.	Chapter 12	208-211		
			b. Distinct tRNA molecules bind specific amino acids and have anti-codon sequences that base pair with the mRNA. tRNA is recruited to the ribosome during translation to generate the primary peptide sequence based on the mRNA sequence.	Chapter 12	208, 212-214		
			c. rRNA molecules are functional building blocks of ribosomes.	Chapter 12	208, 214-216		
			IST-1.N.2: Genetic information flows from a sequence of nucleotides in DNA to a sequence of bases in an mRNA molecule to a sequence of amino acids in a protein.	Chapter 12	210-216		
			IST-1.N.3: 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.	Chapter 12	210-212		
			IST-1.N.4: The DNA strand acting as the template strand is also referred to as the noncoding strand, minus strand, or antisense strand. Selection of which DNA strand serves as the template strand depends on the gene being transcribed.	Chapter 12	212-216		
			IST-1.N.5: The enzyme RNA polymerase synthesizes mRNA molecules in the 5' to 3' direction by reading the template DNA strand in the 3' to 5' direction.	Chapter 12	210-211		
			IST-1.N.6: In eukaryotic cells the mRNA transcript undergoes a series of enzyme-regulated modifications– **a.** Addition of a poly-A tail. **b.** Addition of a GTP cap. **c.** Excision of introns and splicing and retention of exons. **d.** Excision of introns and splicing and retention of exons can generate different versions of the resulting mRNA molecule; this is known as alternative splicing.	Chapter 12	210-212		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
6.4: Translation	**IST-1:** Heritable information provides for continuity of life.	**IST-1.O:** Describe how the phenotype of an organism is determined by its genotype.	**IST-1.O.1:** Translation of the mRNA to generate a polypeptide occurs on ribosomes that are present in the cytoplasm of both prokaryotic and eukaryotic cells, and on the rough endoplasmic reticulum of eukaryotic cells.	Chapter 12	212-216	**6.E.a:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on biological concepts or processes.	Chapter 12, p. 218, AP Assessment, q. 5
			IST-1.O.2: In prokaryotic organisms, translation of the mRNA molecule occurs while it is being transcribed.	Chapter 12	215	**2.D.b:** Represent relationships within biological models, including diagrams.	Chapter 20, p. 365, AP Assessment, q. 2
			IST-1.O.3: Translation involves energy and many sequential steps, including initiation, elongation, and termination. *Exclusion Statement--The details and names of the enzymes and factors involved in each of these steps are beyond the scope of the course and the AP Exam.*	Chapter 12	212-216		
			IST-1.O.4: The salient features of translation include– **a.** Translation is initiated when the rRNA in the ribosome interacts with the mRNA at the start codon.	Chapter 12	212-216		
			b. The sequence of nucleotides on the mRNA is read in triplets called codons.	Chapter 12	209-210, 213		
			c. 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.	Chapter 12	209-210, 213		
			d. Nearly all living organisms use the same genetic code, which is evidence for the common ancestry of all living organisms.	Chapter 12	209-210		
			e. tRNA brings the correct amino acid to the correct place specified by the codon on the mRNA.	Chapter 12	210, 212-216		
			f. The amino acid is transferred to the growing polypeptide chain.	Chapter 12	212-213		
			g. The process continues along the mRNA until a stop codon is reached.	Chapter 12	215-216		
			h. The process terminates by release of the newly synthesized polypeptide/protein. *Exclusion Statement--Memorization of the genetic code is beyond the scope of the course and the AP Exam.*	Chapter 12	215-216		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
			IST-1.O.5: Genetic information in retroviruses is a special case and has an alternate flow of information: from RNA to DNA, made possible by reverse transcriptase, an enzyme that copies the viral RNA genome into DNA. This DNA integrates into the host genome and becomes transcribed and translated for the assembly of new viral progeny. *Exclusion Statement--The names of the steps and particular enzymes involved—beyond DNA polymerase, ligase, RNA polymerase, helicase and topoisomerase—are beyond the scope of the course and the AP Exam.*	Chapter 20	353-355	**2.D.b:** Represent relationships within biological models, including diagrams.	Chapter 20, p. 365, AP Assessment, q. 2
6.5: Regulation of Gene Expression	**IST-2:** Differences in the expression of genes account for some of the phenotypic differences between organisms.	**IST-2.A:** Describe the types of interactions that regulate gene expression.	**IST-2.A.1:** Regulatory sequences are stretches of DNA that interact with regulatory proteins to control transcription.	Chapter 13	220-232	**6.A:** Make a scientific claim.	Chapter 13, p. 226, Questions to Consider, 1-2
			IST-2.A.2: Epigenetic changes can affect gene expression through reversible modifications of DNA or histones.	Chapter 13	223-227		
			IST-2.A.3: The phenotype of a cell or organism is determined by the combination of genes that are expressed and the levels at which they are expressed–	Chapter 11; Chapter 13	183; 233		
			a. Observable cell differentiation results from the expression of genes for tissue-specific proteins.	Chapter 13	233		
			b. Induction of transcription factors during development results in sequential gene expression.	Chapter 13	227-233		
		IST-2.B: Explain how the location of regulatory sequences relates to their function.	**IST-2.B.1:** Both prokaryotes and eukaryotes have groups of genes that are coordinately regulated–	Chapter 13	220-232		Chapter 13, p. 235, AP Assessment, q. 6
			a. In prokaryotes, groups of genes called operons are transcribed in a single mRNA molecule. The *lac* operon is an example of an inducible system.	Chapter 13	220-223		
			b. In eukaryotes, groups of genes may be influenced by the same transcription factors to coordinately regulate expression.	Chapter 13	223-231		
6.6: Gene Expression and Cell Specialization	**IST-2:** Differences in the expression of genes account for some of the phenotypic differences between organisms.	**IST-2.C:** Explain how the binding of transcription factors to promoter regions affects gene expression and/or the phenotype of the organism.	**IST-2.C.1:** Promoters are DNA sequences upstream of the transcription start site where RNA polymerase and transcription factors bind to initiate transcription.	Chapter 13	220, 227	**6.B:** Support a claim with evidence from biological principles, concepts, processes and/or data.	Chapter 13, p. 222, Check Your Progress, q. 3
			IST-2.C.2: Negative regulatory molecules inhibit gene expression by binding to DNA and blocking transcription.	Chapter 13	222, 224		

Topic Name # of Class Periods	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
		IST-2.D: Explain the connection between the regulation of gene expression and phenotypic differences in cells and organisms.	**IST-2.D.1:** Gene regulation results in differential gene expression and influences cell products and function.	Chapter 13	220-232	**6.B:** Support a claim with evidence from biological principles, concepts, processes and/or data.	Chapter 13, p. 231, Check Your Progress, q. 3
			IST-2.D.2: Certain small RNA molecules have roles in regulating gene expression.	Chapter 13	230-231		
6.7: Mutations	**IST-2:** Differences in the expression of genes account for some of the phenotypic differences between organisms.	**IST-2.E:** Describe the various types of mutation.	**IST-2.E.1:** Changes in genotype can result in changes in phenotype– **a.** The function and amount of gene products determine the phenotype of organisms– **i.** The normal function of the genes and gene products collectively comprises the normal function of organisms. **ii.** Disruptions in genes and gene products cause new phenotypes.	Chapter 11; Chapter 13	183-195; 232-234	**2.C:** Explain how the visual representation relates to or illustrates biological principles, concepts, processes and/or theories.	Chapter 13, p. 235, AP Assessment, q. 5
			Illustrative Examples: · Mutations in the CFTR gene disrupt ion transport and result in cystic fibrosis. · Mutations in the *MC1R* gene give adaptive melanism in pocket mice.	Chapter 11; Chapter 35	189; 653		
			IST-2.E.2: Alterations in a DNA sequence can lead to changes in the type or amount of the protein produced and the consequent phenotype. DNA mutations can be positive, negative, or neutral based on the effect or the lack of effect they have on the resulting nucleic acid or protein and the phenotypes that are conferred by the protein.	Chapter 13	232-234		
	IST-4: The processing of genetic information is imperfect and is a source of genetic variation.	**IST-4.A:** Explain how changes in genotype may result in changes in phenotype.	**IST-4.A.1:** Errors in DNA replication or DNA repair mechanisms, and external factors, including radiation and reactive chemicals, can cause random mutations in the DNA– **a.** Whether a mutation is detrimental, beneficial, or neutral depends on the environmental context. **b.** Mutations are the primary source of genetic variation.	Chapter 5; Chapter 9; Chapter 10; Chapter 12; Chapter 13; Chapter 15; Chapter 28	83; 144; 163-176; 193; 208; 232-234; 261-262; 277-287	**3.D:** Make observations or collect data from representations of laboratory setups or results.	Chapter 13, p. 235 AP Assessment, q. 5
			IST-4.A.2: Errors in mitosis or meiosis can result in changes in phenotype– **a.** Changes in chromosome number often result in new phenotypes, including sterility caused by triploidy, and increased vigor of other polyploids. **b.** Changes in chromosome number often result in human disorders with developmental limitations, including Down syndrome/Trisomy 21 and Turner syndrome.	Chapter 9; Chapter 10	144; 165-176		Chapter 10, p. 178 AP Assessment, q. 13

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
		IST-4.B: Explain how alterations in DNA sequences contribute to variation that can be subject to natural selection.	**IST-4.B.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–	Chapter 11; Chapter 15; Chapter 16; Chapter 47	183-184, 194, 206-207; 259-264; 274-278, 283, 286; 883		Chapter 16, p. 289, AP Assessment, q. 10
			a. The horizontal acquisitions of genetic information primarily in prokaryotes via transformation (uptake of naked DNA), transduction (viral transmission of genetic information), conjugation (cell-to-cell transfer of DNA), and transposition (movement of DNA segments within and between DNA molecules) increase variation.	Chapter 14; Chapter 20; Chapter 21	248-249; 358; 379-380		
			b. Related viruses can combine/recombine genetic information if they infect the same host cell.	Chapter 20	355		
			c. Reproduction processes that increase genetic variation are evolutionarily conserved and are shared by various organisms.	Chapter 4; Chapter 10; Chapter 20; Chapter 27; Chapter 41	56; 163-165; 358; 495; 745-746		
			Illustrative Examples: *· Antibiotic resistance mutations.*	Chapter 16	283		
			· Pesticide resistance mutations.	Chapter 47	883		
			· Sickle cell disorder and heterozygote advantage.	Chapter 11; Chapter 13	192-193; 233		
6.8: Biotechnology	**IST-1:** Heritable information provides for continuity of life.	**IST-1.P:** Explain the use of genetic engineering techniques in analyzing or manipulating DNA.	**IST-1.P.1:** Genetic engineering techniques can be used to analyze and manipulate DNA and RNA–	Chapter 14	237-252	**6.D:** Explain the relationship between experimental results and larger biological concepts, processes, or theories.	Chapter 14, p. 253, AP Assessment, q. 10
			a. Electrophoresis separates molecules according to size and charge.	Chapter 14	238-240		
			b. During polymerase chain reaction (PCR) DNA fragments are amplified.	Chapter 14	238		
			c. Bacterial transformation introduces DNA into bacterial cells.	Chapter 14	240-246		
			d. DNA sequencing determines the order of nucleotides in a DNA molecule.	Chapter 14	247-252		
			Illustrative Examples: *· Amplified DNA fragments can be used to identify organisms and perform phylogenetic analyses.* *· Analysis of DNA can be used for forensic identification.* *· Genetically modified organisms include transgenic animals.* *· Gene cloning allows propagation of DNA fragments.* *Exclusion Statement--The details of these processes are beyond the scope of this course. The focus should be on the conceptual understanding of the application of these techniques.*	Chapter 14	237-239; 240-243		

Unit 7: Natural Selection

13-20%

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
7.1: Introduction to Natural Selection	**EVO-1:** Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.	**EVO-1.C:** Describe the causes of natural selection.	**EVO-1.C.1:** Natural selection is a major mechanism of evolution.	Chapter 1; Chapter 15; Chapter 16	6; 261-262; 279-286	**2.A:** Describe the relationships between components of a visual representation (of a concept, process, or model).	Chapter 15, p. 271-272, AP Assessment, q. 12
			EVO-1.C.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 traits to subsequent generations.	Chapter 1; Chapter 15; Chapter 16	6-9; 256-270; 274-287		
		EVO-1.D: Explain how natural selection affects populations.	**EVO-1.D.1:** Evolutionary fitness is measured by reproductive success.	Chapter 1; Chapter 15; Chapter 16	6-9; 256-270; 280-287		Chapter 16, p. 285, Check Your Progress, q. 2; Chapter 16, p. 289, AP Assessment, q. 8
			EVO-1.D.2: Biotic and abiotic environments can be more or less stable/fluctuating, and this affects the rate and direction of evolution; different genetic variations can be selected in each generation.	Chapter 15; Chapter 16	256-270; 274-287		
7.2: Natural Selection	**EVO-1:** Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.	**EVO-1.E:** Describe the importance of phenotypic variation in a population.	**EVO-1.E.1:** Natural selection acts on phenotypic variations in populations.	Chapter 1; Chapter 15; Chapter 16	6-9; 256-270; 274-277	**1.B:** Explain biological concepts and/or processes.	Chapter 15, p. 271, AP Assessment, q. 11
			EVO-1.E.2: Environments change and apply selective pressures to populations.	Chapter 15; Chapter 16	261-264, 271; 274-277, 280-287		
			Illustrative Examples: *· Flowering time in relation to global climate change.*	Chapter 26	474, 479-480		
			· Peppered moth	Chapter 15; Chapter 16	264; 274-277		
			EVO-1.E.3: Some phenotypic variations significantly increase or decrease fitness of the organism in particular environments.	Chapter 10; Chapter 15; Chapter 16	163-165; 261-264; 280-287		
			Illustrative Examples: *· Sickle cell anemia*	Chapter 11; Chapter 16	192; 286-287		
			· DDT resistance in insects.	Chapter 47	883		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
7.3: Artificial Selection	**EVO-1:** Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.	**EVO-1.F:** Explain how humans can affect diversity within a population.	**EVO-1.F.1:** Through artificial selection, humans affect variation in other species.	Chapter 15; Chapter 23	262; 418	**4.B.c:** Describe data from a table or graph, including describing relationships between variables.	Chapter 23, p. 418, Questions to Consider, q. 1
		EVO-1.G: Explain the relationship between changes in the environment and evolutionary changes in the population.	**EVO-1.G.1:** Convergent evolution occurs when similar selective pressures result in similar phenotypic adaptations in different populations or species.	Chapter 17; Chapter 19	301; 340-347		Chapter 17, p. 301, Check Your Progress, q. 3
7.4: Population Genetics	**EVO-1:** Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.	**EVO-1.H:** Explain how random occurrences affect the genetic makeup of a population.	**EVO-1.H.1:** Evolution is also driven by random occurrences– **a.** Mutation is a random process that contributes to evolution.	Chapter 16	274-279	**3.B:** State the null and alternative hypotheses or predict the results of an experiment.	Chapter 16, p. 279, Check Your Progress, q. 1
			b. Genetic drift is a nonselective process occurring in small populations– **i.** Bottlenecks. **ii.** Founder effect.	Chapter 16	274-279		
			c. Migration/gene flow can drive evolution.	Chapter 16	274-287		
		EVO-1.I: Describe the role of random processes in the evolution of specific populations.	**EVO-1.I.1:** Reduction of genetic variation within a given population can increase the differences between populations of the same species.	Chapter 16	274-279, 289		Chapter 16, p. 289, AP Assessment , q. 12
		EVO-1.J: Describe the change in the genetic makeup of a population over time.	**EVO-1.J.1:** Mutation results in genetic variation, which provides phenotypes on which natural selection acts.	Chapter 16; Chapter 17	277-278; 289; 304-305		Chapter 15, p. 289, AP Assessment, q. 11, 13
7.5: Hardy-Weinberg Equilibrium	**EVO-1:** Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.	**EVO-1.K:** Describe the conditions under which allele and genotype frequencies will change in populations.	**EVO-1.K.1:** Hardy-Weinberg is a model for describing and predicting allele frequencies in a nonevolving population. Conditions for a population or an allele to be in Hardy-Weinberg equilibrium are (1) a large population size, (2) absence of migration, (3) no net mutations, (4) random mating, and (5) absence of selection. These conditions are seldom met, but they provide a valuable null hypothesis.	Chapter 16	274-287	**5.A.a:** Perform mathematical calculations, including mathematical equations in the curriculum.	Chapter 16, p. 279, Check Your Progress, q. 2
			EVO-1.K.2: Allele frequencies in a population can be calculated from genotype frequencies. RELEVANT EQUATION Hardy-Weinberg Equation— $p^2 + 2pq + q^2 = 1$ $p + q = 1$ where: p = frequency of allele 1 in the population q = frequency of allele 2 in the population	Chapter 16	274-287, 289	**1.C:** Explain biological concepts, processes, and/or models in applied contexts.	Chapter 16, p. 279, Check Your Progress, q. 1

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
7.5: Hardy-Weinberg Equilibrium	**EVO-1:** Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.	**EVO-1.K:** Describe the conditions under which allele and genotype frequencies will change in populations.	*Illustrative Example–* *· Graphical analysis of allele frequencies in a population.*	Chapter 16	275-276	**1.C:** Explain biological concepts, processes, and/or models in applied contexts.	Chapter 16, p. 279, Check Your Progress, q. 1
		EVO-1.L: Explain the impacts on the population if any of the conditions of Hardy-Weinberg are not met.	**EVO-1.L.1:** Changes in allele frequencies provide evidence for the occurrence of evolution in a population.	Chapter 16	274-287	**5.A.a:** Perform mathematical calculations, including mathematical equations in the curriculum.	Chapter 16, p. 288, AP Assessment, q. 2
			EVO-1.L.2: Small populations are more susceptible to random environmental impact than large populations.	Chapter 15; Chapter 16	256-270; 274-287	**1.C:** Explain biological concepts, processes, and/or models in applied contexts.	Chapter 16, p. 288, AP Assessment, q. 3
7.6: Evidence for Evolution	**EVO-1:** Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.	**EVO-1.M:** Describe the types of data that provide evidence for evolution.	**EVO-1.M.1:** Evolution is supported by scientific evidence from many disciplines (geographical, geological, physical, biochemical, and mathematical data).	Chapter 15; Chapter 18; Chapter 19; Chapter 29	259-269, 271; 317-321; 337-343; 533-534	4.**B.a:** Describe data from a table or graph, including identifying specific data points.	Chapter 18, p. 329, AP Assessment, q. 11
		EVO-1.N: Explain how morphological, biochemical, and geologic data provide evidence that organisms have changed over time.	**EVO-1.N.1:** Molecular, morphological, and genetic evidence from extant and extinct organisms adds to our understanding of evolution–	Chapter 15; Chapter 16; Chapter 17; Chapter 19	259-269; 274-279; 300-307; 337-343		
			a. Fossils can be dated by a variety of methods. These include– **i.** The age of the rocks where a fossil is found **ii.** The rate of decay of isotopes including carbon-14 **iii.** Geographical data	Chapter 18	317-318, 326-328		
			b. Morphological homologies, including vestigial structures, represent features shared by common ancestry.	Chapter 15; Chapter 17	256, 267-268; 300-301		
			EVO-1.N.2: A comparison of DNA nucleotide sequences and/or protein amino acid sequences provides evidence for evolution and common ancestry.	Chapter 15; Chapter 16; Chapter 17	268; 274-279; 302-307		
7.7: Common Ancestry	**EVO-2:** Organisms are linked by lines of descent from common ancestry.	**EVO-2.B:** Describe the fundamental molecular and cellular features shared across all domains of life, which provide evidence of common ancestry.	**EVO-2.B.1:** Many fundamental molecular and cellular features and processes are conserved across organisms.	Chapter 4; Chapter 6; Chapter 12; Chapter 29	55-60; 99-107; 211-216; 533		Chapter 19, p. 45, AP Assessment, q. 10
			EVO-2.B.2: Structural and functional evidence supports the relatedness of organisms in all domains.	Chapter 4; Chapter 6; Chapter 12; Chapter 15; Chapter 16; Chapter 19; Chapter 29	55-60, 70-76; 99-107; 201-202, 208-209, 211-216; 259-269; 274-279; 329-343; 533		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
7.7: Common Ancestry	**EVO-2:** Organisms are linked by lines of descent from common ancestry.	**EVO-2.C:** Describe structural and functional evidence on cellular and molecular levels that provides evidence for the common ancestry of all eukaryotes.	**EVO-2.C.1:** Structural evidence indicates common ancestry of all eukaryotes–	Chapter 4; Chapter 12; Chapter 17	62-76; 208, 211; 309	**6.E.b:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	Chapter 4, p. 78, AP Assessment, q. 5
			a. Membrane-bound organelles	Chapter 4; Chapter 17	62-65; 309		
			b. Linear chromosomes	Chapter 12	208		
			c. Genes that contain introns	Chapter 12; Chapter 17	211; 309		
7.8: Continuing Evolution	**EVO-3:** Life continues to evolve within a changing environment.	**EVO-3.A:** Explain how evolution is an ongoing process in all living organisms.	**EVO-3.A.1:** Populations of organisms continue to evolve.	Chapter 15; Chapter 17; Chapter 20; Chapter 32; Chapter 37	261-264; 291-306; 353-355, 360-361; 588-589; 675-678	**3.E.a:** Propose a new/next investigation based on an evaluation of the evidence from an experiment.	Chapter 47, p.893, AP Assessment q. 9
			EVO-3.A.2: All species have evolved and continue to evolve–	Chapter 15; Chapter 17; Chapter 20	259-265; 291-307; 353-355, 360-361		
			a. Genomic changes over time.	Chapter 15; Chapter 17	267; 306		
			b. Continuous change in the fossil record.	Chapter 15; Chapter 17	264-265; 291-306		
			c. Evolution of resistance to antibiotics, pesticides, herbicides, or chemotherapy drugs.	Chapter 15; Chapter 20; Chapter 47	264; 360-361;883		
			d. Pathogens evolve and cause emergent diseases.	Chapter 20	353-355		
7.9: Phylogeny	**EVO-3:** Life continues to evolve within a changing environment.	**EVO-3.B:** Describe the types of evidence that can be used to infer an evolutionary relationship.	**EVO-3.B.1:** Phylogenetic trees and cladograms show evolutionary relationships among lineages–	Chapter 19; Chapter 29; Chapter 30	338-343; 534; 553-554	**2.D.c:** Represent relationships within biological models, including flow charts.	Chapter 19, p. 345,, AP Assessment, q. 10
			a. Phylogenetic trees and cladograms both show relationships between lineages, but phylogenetic trees show the amount of change over time calibrated by fossils or a molecular clock.	Chapter 19; Chapter 29; Chapter 30	338-343; 534; 553-554		
			b. Traits that are either gained or lost during evolution can be used to construct phylogenetic trees and cladograms– **i.** Shared characters are present in more than one lineage. **ii.** Shared, derived characters indicate common ancestry and are informative for the construction of phylogenetic trees and cladograms. **iii.** The outgroup represents the lineage that is least closely related to the remainder of the organisms in the phylogenetic tree or cladogram.	Chapter 19	338-343		
			c. Molecular data typically provide more accurate and reliable evidence than morphological traits in the construction of phylogenetic trees or cladograms.	Chapter 19; Chapter 30	342-343; 553-555		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
		EVO-3.C: Explain how a phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness.	**EVO-3.C.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 19; Chapter 29; Chapter 30	338-340; 534; 553-555	**2.D.c:** Represent relationships within biological models, including flow charts.	Chapter 19, p. 343, Check Your Progress, q. 1, 2
			EVO-3.C.2: Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species and from DNA and protein sequence similarities.	Chapter 19	340-343		
			EVO-3.C.3: Phylogenetic trees and cladograms represent hypotheses and are constantly being revised, based on evidence.	Chapter 19	338-343		
7.10: Speciation	**EVO-3:** Life continues to evolve within a changing environment.	**EVO-3.D:** Describe the conditions under which new species may arise.	**EVO-3.D.1:** Speciation may occur when two populations become reproductively isolated from each other.	Chapter 17	293-299	**6.E.a:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on biological concepts or processes.	Chapter 17, p. 309, Assessing the Big Ideas, Free Response, q. 8
			EVO-3.D.2: The Biological Species Concept provides a commonly used definition of 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.	Chapter 17	293		
		EVO-3.E: Describe the rate of evolution and speciation under different ecological conditions.	**EVO-3.E.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.	Chapter 17	304-307	**2.B.a:** Explain biological concepts and/or processes represented visually in theoretical contexts.	Chapter 17, p. 307, Check Your Progress, q. 1
			EVO-3.E.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.	Chapter 17; Chapter 29	300-304; 547-549		
		EVO-3.F: Explain the processes and mechanisms that drive speciation.	**EVO-3.F.1:** Speciation results in diversity of life forms.	Chapter 17	291-292, 304-307		Chapter 17, p. 308 AP Assessment, q. 3
			EVO-3.F.2: Speciation may be sympatric or allopatric.	Chapter 17	396-299		
			EVO-3.F.3: Various prezygotic and postzygotic mechanisms can maintain reproductive isolation and prevent gene flow between populations.	Chapter 17	293-299		
			Illustrative Examples: *· Hawaiian Drosophila* *· Caribbean Anolis* *· Apple maggot Rhagoletis*	Chapter 17	300; 305		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
7.11: Extinction	**EVO-3:** Life continues to evolve within a changing environment.	**EVO-3.G:** Describe factors that lead to the extinction of a population.	**EVO-3.G.1:** Extinctions have occurred throughout Earth's history.	Chapter 18; Chapter 47	319, 327-328;885-890	**3.B:** State the null or alternative hypotheses or predict the results of an experiment.	Chapter 18, p. 328, Check Your Progress, q. 3
			EVO-3.G.2: Extinction rates can be rapid during times of ecological stress.	Chapter 18; Chapter 47	327-328; 885-890		
		EVO-3.H: Explain how the risk of extinction is affected by changes in the environment.	**EVO-3.H.1:** Human activity can drive changes in ecosystems that cause extinctions.	Chapter 30; Chapter 47	562-563; 885-890		Chapter 47, p. 893, AP Assessment, q. 10
		EVO-3.I: Explain species diversity in an ecosystem as a function of speciation and extinction rates.	**EVO-3.I.1:** The amount of diversity in an ecosystem can be determined by the rate of speciation and the rate of extinction.	Chapter 47	887		Chapter 47, p. 887, Questions to Consider, q. 2
		EVO-3.J: Explain how extinction can make new environments available for adaptive radiation.	**EVO-3.J.1:** Extinction provides newly available niches that can then be exploited by different species.	Chapter 45	834-835		Chapter 45, p. 855, AP Assessment, q. 1
7.12: Variations in Populations	**SYI-3:** Naturally occurring diversity among and between components within biological systems affects interactions with the environment	**SYI-3.D:** Explain how the genetic diversity of a species or population affects its ability to withstand environmental pressures.	**SYI-3.D.1:** The level of variation in a population affects population dynamics–	Chapter 15; Chapter 16	259-264; 279-280	**6.C:** Provide reasoning to justify a claim by connecting evidence to biological.	Chapter 16, p. 289, AP Assessment, q. 10
			a. Population ability 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.	Chapter 16	278-280		
			Illustrative Examples: · *California condors* · *Black-footed ferrets* · *Prairie chickens* · *Potato blight* · *Corn rust*	Chapter 22; Chapter 47	396-397; 881		
			b. Genetically diverse populations are more resilient to environmental perturbation because they are more likely to contain individuals who can withstand the environmental pressure.	Chapter 15; Chapter 16	259-264; 274-278		
			c. Alleles that are adaptive in one environmental condition may be deleterious in another because of different selective pressures.	Chapter 16	276-278, 280-283, 286-287		
			Illustrative Examples: · *Antibiotic resistance in bacteria.*	Chapter 16	283		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
7.13: Origins of Life on Earth	**SYI-3:** Naturally occurring diversity among and between components within biological systems affects interactions with the environment	**SYI-3.E:** Describe the scientific evidence that provides support for models of the origin of life on Earth.	**SYI-3.E.1:** Several hypotheses about the origin of life on Earth are supported with scientific evidence–	Chapter 18	311-316	**3.B:** State the null hypotheses or predict the results of an experiment.	Chapter 18, p. 329, AP Assessment, q. 10
			a. Geological evidence provides support for models of the origin of life on Earth– **i.** Earth formed approximately 4.6 billion years ago (bya). The environment was too hostile for life until 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 when the origin of life could have occurred.	Chapter 18	314-318		
			b. There are several models about the origin of life on Earth- **i.** Primitive Earth provided inorganic precursors from which organic molecules could have been synthesized because of the presence of available free energy and the absence of a significant quantity of atmospheric oxygen (O2). **ii.** Organic molecules could have been transported to Earth by a meteorite or other celestial event.	Chapter 18	312-314		
			c. Chemical experiments have shown that it is possible to form complex organic molecules from inorganic molecules in the absence of life– **i.** Organic molecules/monomers served as building blocks for the formation of more complex molecules, including amino acids and nucleotides. **ii.** The joining of these monomers produced polymers with the ability to replicate, store, and transfer information.	Chapter 18	311-313		
			SYI-3.E.2: The RNA World Hypothesis proposes that RNA could have been the earliest genetic material.	Chapter 18	313		

Unit 8: Ecology

10-15%

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
8.1: Responses to the Environment	**ENE-3:** Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.	**ENE-3.D:** Explain how the behavioral and/or physiological response of an organism is related to changes in internal or external environment.	**ENE-3.D.1:** Organisms respond to changes in their environment through behavioral and physiological mechanisms.	Chapter 24, Chapter 26, Chapter 27, Chapter 31, Chapter 40, Chapter 43	429-430; 474-480; 488-489; 578-581; 730-741; 788-803	**3.C.a:** Identify experimental procedures that are aligned to the question, including identifying dependent and independent variables.	Chapter 43, p. 804, AP Assessment, q. 1-3
			Illustrative Examples: *• Photoperiodism and phototropism in plants.* *• Taxis and kinesis in animals* *• Nocturnal and diurnal activity.* *Exclusion Statement--No specific behavioral or physiological mechanism is required for teaching this concept.*	Chapter 26; Chapter 27; Chapter 40	477-479; 488-489; 740		
			ENE-3.D.2: Organisms exchange information with one another in response to internal changes and external cues, which can change behavior.	Chapter 26; Chapter 40; Chapter 43; Chapter 45	472-473; 735-736; 740; 795-803; 835-839		
			Illustrative Examples: *• Fight-or-flight response.*	Chapter 40	735-736		
			• Predator warnings	Chapter 45	837		
			• Plant responses to herbivory	Chapter 26	472		
	IST-5: Transmission of information results in changes within and between biological systems.	**IST-5.A:** Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of the population.	**IST-5.A.1:** Individuals can act on information and communicate it to others.	Chapter 26; Chapter 37; Chapter 38; Chapter 43; Chapter 45	478-479; 670-672; 692-707; 791-803; 836-837		Chapter 43, p. 804, AP Assessment, q. 3, 5
			IST-5.A.2: Communication occurs through various mechanisms–	Chapter 37; Chapter 38; Chapter 43; Chapter 45	670-672; 692-707; 795-803; 836-837		
			a. Organisms have a variety of signaling behaviors that produce changes in the behavior of other organisms and can result in differential reproductive success.	Chapter 23; Chapter 43	420-422; 795-798		
			Illustrative Examples: *• Territorial marking in mammals.*	Chapter 43	797		
			• Coloration in flowers.	Chapter 23; Chapter 26; Chapter 38	420-422; 478-479; 695-696		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
			b. Animals use visual, audible, tactile, electrical, and chemical signals to indicate dominance, find food, establish territory, and ensure reproductive success.	Chapter 23; Chapter 26; Chapter 38; Chapter 43; Chapter 45	420-422; 478-479; 692-707; 792; 800; 836-837	**3.C.a:** Identify experimental procedures that are aligned to the question, including identifying dependent and independent variables.	Chapter 43, p. 804, AP Assessment, q. 1-3
			Illustrative Examples: *• Bird songs.*	Chapter 43	792		
			• Pack behavior in animals.	Chapter 16	284		
			• Predator warnings.	Chapter 43; Chapter 45	800; 836-837		
			• Coloration	Chapter 26; Chapter 45	479; 837		
			IST-5.A.3: Responses to information and communication of information are vital to natural selection and evolution–	Chapter 23; Chapter 26; Chapter 37; Chapter 43; Chapter 45	420-422; 478-479; 670-672; 788-802; 837-838		
			a. Natural selection favors innate and learned behaviors that increase survival and reproductive fitness.	Chapter 43	788-795		
			Illustrative Examples: *• Parent and offspring interactions.*	Chapter 43	788-795		
			• Courtship and mating behaviors.	Chapter 43	798-802		
			• Foraging in bees and other animals.	Chapter 43	797-798		
			b. Cooperative behavior tends to increase the fitness of the individual and the survival of the population.	Chapter 43; Chapter 45	800-802; 838		
			Illustrative Examples: *• Pack behavior in animals.*	Chapter 44	815-817		
			• Herd, flock and schooling behavior in animals.	Chapter 44	815-817		
			• Predator warnings.	Chapter 43; Chapter 45	800; 836-837		
			• Colony and swarming behavior in insects.	Chapter 43	800		
			• Kin selection. *Exclusion Statement – The details of the various communications and community behavioral systems are beyond the scope of the course and the AP Exam.*	Chapter 43	802		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
8.2: Energy Flow through Ecosystems	**ENE-1:** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.	**ENE-1.M:** Describe the strategies organisms use to acquire and use energy.	**ENE-1.M.1:** Organisms use energy to maintain organization, grow, and reproduce–	Chapter 4; Chapter 6; Chapter 45	71-72; 97-98; 842-847	**6.D:** Explain the relationship between experimental results and larger biological concepts, processes, or theories.	Chapter 43, p. 805, AP Assessment, q. 9
			a. Organisms use different strategies to regulate body temperature and metabolism– **i.** Endotherms use thermal energy generated by metabolism to maintain homeostatic body temperatures. **ii.** Ectotherms lack efficient internal mechanisms for maintaining body temperature, though they may regulate their temperature behaviorally by moving into the sun or shade or by aggregating with other individuals.	Chapter 6; Chapter 18; Chapter 29	103; 323-326;539;542;546-547		
			b. Different organisms use various reproductive strategies in response to energy availability.	Chapter 22; Chapter 24; Chapter 27; Chapter 28; Chapter 29; Chapter 43; Chapter 45	393-395; 427, 430; 495; 511-512; 516; 539; 799-800; 834		
			Illustrative Examples: • *Seasonal reproduction in animals and plants.*	Chapter 24; Chapter 45	427; 834		
			• Life-history strategy (biennial plants, reproductive diapause).	Chapter 24	430		
			c. There is a relationship between metabolic rate per unit body mass and the size of multicellular organisms—generally, the smaller the organism, the higher the metabolic rate.	Chapter 18	324		
			d. A net gain in energy results in energy storage or the growth of an organism.	Chapter 6; Chapter 43	97-98; 798-799		
			e. A net loss of energy results in loss of mass and, ultimately, the death of an organism.	Chapter 6	104-105		
		ENE-1.N: Explain how changes in energy availability affect populations and ecosystems.	**ENE-1.N.1:** Changes in energy availability can result in changes in population size.	Chapter 45	844-847		Chapter 45, p. 856, AP Assessment, q. 11
			Illustrative Examples: • *Food chains/webs.*	Chapter 45	844-847		
			• *Trophic pyramids/diagrams.*	Chapter 45	844-845		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
			ENE.1.N.2: Changes in energy availability can result in disruptions to an ecosystem–	Chapter 45	844-847	**6.D:** Explain the relationship between experimental results and larger biological concepts, processes, or theories.	Chapter 45, p. 856, AP Assessment, q. 11
			a. A change in energy resources such as sunlight can affect the number and size of the trophic levels.	Chapter 45; Chapter 46	845-846; 875		
			b. A change in the producer level can affect the number and size of other trophic levels.	Chapter 45	844-846		
		ENE-1.O: Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem.	**ENE-1.O.1:** Autotrophs capture energy from physical or chemical sources in the environment–	Chapter 7; Chapter 45	110; 843, 845		Chapter 22, p. 401, AP Assessment, q. 4
			a. Photosynthetic organisms capture energy present in sunlight.	Chapter 7	110-112		
			b. Chemosynthetic organisms capture energy from small inorganic molecules present in their environment, and this process can occur in the absence of oxygen.	Chapter 18; Chapter 45	315; 843		
			ENE-1.O.2: Heterotrophs capture energy present in carbon compounds produced by other organisms–	Chapter 7; Chapter 45	110; 843-844		
			a. Heterotrophs may metabolize carbohydrates, lipids, and proteins as sources of energy by hydrolysis.	Chapter 3	36-37		
8.3: Population Ecology	**SYI-1:** Living systems are organized in a hierarchy of structural levels that interact.	**SYI-1.G:** Describe factors that influence growth dynamics of populations.	**SYI-1.G.1:** Populations comprise individual organisms that interact with one another and with the environment in complex ways.	Chapter 44	808-827	**4.A:** Construct a graph, plot, or chart.	Chapter 44, p. 815, Check Your Progress q. 1; Chapter 44, p. 829, AP Assessment, q. 9
			SYI-1.G.2: Many adaptations in organisms are related to obtaining and using energy and matter in a particular environment–	Chapter 44	812; 817-820		
			a. Population growth dynamics depend on a number of factors– **RELEVANT EQUATION** Population Growth— $\frac{dN}{dt} = B - D$ where: dt = chage in time B = birth rate D = death rate N = population size	Chapter 44	813-817		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
			i. Reproduction without constraints results in the exponential growth of a population. **RELEVANT EQUATION** Exponential Growth— $\frac{dN}{dt} = r_{max}N$ where: dt = change in time N = population size r_{max} = maximum per capita growth rate of population	Chapter 44	813-817	**4.A:** Construct a graph, plot, or chart.	Chapter 44, p. 815, Check Your Progress q. 1; Chapter 44, p. 829, AP Assessment, q. 9
8.4: Effect of Density on Populations	**SYI-1:** Living systems are organized in a hierarchy of structural levels that interact.	**SYI-1.H:** Explain how the density of a population affects and is determined by resource availability in the environment.	**SYI-1.H.1:** A population can produce a density of individuals that exceeds the system's resource availability.	Chapter 44	816-817	**5.A.c:** Perform mathematical calculations, including rates.	Chapter 44, p. 828, AP Assessment, q. 6
			SYI-1.H.2: As limits to growth due to density-dependent and density-independent factors are imposed, a logistic growth model generally ensues. **RELEVANT EQUATION** $\frac{dN}{dt} = r_{max}N\left(\frac{K-N}{K}\right)$ where: dt = change in time N = population size r_{max} = maximum per capita growth rate of population K = carrying capacity	Chapter 44	814-815		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
8.5: Community Ecology	**ENE-4:** Communities and ecosystems change on the basis of interactions among populations and disruptions to the environment.	**ENE-4.A:** Describe the structure of a community according to its species composition and diversity.	**ENE-4.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— $\text{Diversity Index} = 1 - \Sigma\left(\frac{n}{N}\right)^2$ n = the total number of organisms of a particular species N = total number of organisms of all species	Chapter 45	831-833	**5.B:** Use confidence intervals and/or error bars (both determined using standard errors) to determine whether sample means are statistically different.	Chapter 45, p. 856, AP Assessment, q. 10
		ENE-4.B: Explain how interactions within and among populations influence community structure.	**ENE-4.B.1:** Communities change over time depending on interactions between populations.	Chapter 44; Chapter 45	815-822; 832-842; 844-847		
			ENE-4.B.2: Interactions among populations determine how they access energy and matter within a community.	Chapter 43	798-803		
			ENE-4.B.3: Relationships among interacting populations can be characterized by positive and negative effects and can be modeled. Examples include predator/prey interactions, trophic cascades, and niche partitioning.	Chapter 45	832-838; 844-847		
			ENE-4.B.4: Competition, predation, and symbioses, including parasitism, mutualism, and commensalism, can drive population dynamics.	Chapter 45	836-840		
		ENE-4.C: Explain how community structure is related to energy availability in the environment.	**ENE-4.C.1:** Cooperation or coordination between organisms, populations, and species can result in enhanced movement of, or access to, matter and energy.	Chapter 45	831-836; 844-847; 848-851		

Topic Name	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
8.6: Biodiversity	**SYI-3:** Naturally occurring diversity among and between components within biological systems affects interactions with the environment.	**SYI-3.F:** Describe the relationship between ecosystem diversity and its resilience to changes in the environment.	**SYI-3.F.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.	Chapter 47	882-890; 893	**6.E.c:** Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on data.	Chapter 47, p. 893, AP Assessment, q. 5
			SYI-3.F.2: Keystone species, producers, and essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem.	Chapter 45; Chapter 47	831-832; 843-849; 890		
		SYI-3.G: Explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long-term structure.	**SYI-3.G.1:** The diversity of species within an ecosystem may influence the organization of the ecosystem.	Chapter 45; Chapter 47	831-832; 880-885		Chapter 47, p. 893, AP Assessment, q. 5
			SYI-3.G.2: The effects of keystone species on the ecosystem are disproportionate relative to their abundance in the ecosystem, and when they are removed from the ecosystem, the ecosystem often collapses.	Chapter 47	890		
8.7: Disruptions to Ecosystems	**EVO-1:** Evolution is characterized by change in the genetic make-up of a population over time and is supported by multiple lines of evidence.	**EVO-1.O:** Explain the interaction between the environment and random or preexisting variations in populations.	**EVO-1.O.1:** An adaptation is a genetic variation that is favored by selection and is manifested as a trait that provides an advantage to an organism in a particular environment.	Chapter 16	277-278	**5.D.a:** Use data to evaluate a hypothesis (or prediction), including rejecting or failing to reject the null hypothesis.	Chapter 16, p. 289, AP Assessment, q. 13
			EVO-1.O.2: Mutations are random and are not directed by specific environmental pressures.	Chapter 9; Chapter 10; Chapter 11; Chapter 13; Chapter 15; Chapter 18; Chapter 20	152-157;174-176; 185-190; 231-234; 261-269; 316; 353-358	5.D.b: Use data to evaluate a hypothesis (or prediction), including supporting or refuting the alternative hypothesis.	Chapter 9, p. 159, AP Assessment, q. 12

Topic Name # of Class Periods	Enduring Understanding	Learning Objective	Essential Knowledge	Chapter	Page Numbers	Suggested Skills	Page Numbers
	SYI-2: Competition and cooperation are important aspects of biological systems.	**SYI-2.A:** Explain how invasive species affect ecosystem dynamics.	**SYI-2.A.1:** The intentional or unintentional introduction of an invasive species can allow the species to exploit a new niche free of predators or competitors or to outcompete other organisms for resources.	Chapter 47	885-888	**5.D.a:** Use data to evaluate a hypothesis (or prediction), including rejecting or failing to reject the null hypothesis. **5.D.b:** Use data to evaluate a hypothesis (or prediction), including supporting or refuting the alternative hypothesis.	Chapter 47, p. 893, AP Assessment, q. 4, 10
			SYI-2.A.2: The availability of resources can result in uncontrolled population growth and ecological changes.	Chapter 47	885-888		
			Illustrative Examples: *• Kudzu*	Chapter 47	886		
			• Zebra mussels	Chapter 47	886-888		
		SYI-2.B: Describe human activities that lead to changes in ecosystem structure and/or dynamics.	**SYI-2.B.1:** The distribution of local and global ecosystems changes over time.	Chapter 18; Chapter 47	326-328; 880-892	**5.D.a:** Use data to evaluate a hypothesis (or prediction), including rejecting or failing to reject the null hypothesis. **5.D.b:** Use data to evaluate a hypothesis (or prediction), including supporting or refuting the alternative hypothesis.	Chapter 47, p. 893, AP Assessment, q. 4, 9, 10
			SYI-2.B.2: Human impact accelerates change at local and global levels–	Chapter 30; Chapter 47	563; 885-892		
			a. The introduction of new diseases can devastate native species.	Chapter 21; Chapter 22; Chapter 47	370; 396; 881; 885-888		
			Illustrative Examples: *• Dutch elm disease.* *• Potato blight* *• Small pox*	Chapter 22 Chapter 47	396;881		
			b. Habitat change can occur because of human activity.	Chapter 45; Chapter 47	847-854; 885-886		
			Illustrative Examples: *• Global climate change.*	Chapter 45; Chapter 47	851-854; 888-889		
			• Logging	Chapter 47	891		
			• Urbanization	Chapter 47	885-891		
			• Mono-cropping	Chapter 47	881-883		
		SYI-2.C: Explain how geological and meteorological activity leads to changes in ecosystem structure and/or dynamics.	**SYI-2.C.1:** Geological and meteorological events affect habitat change and ecosystem distribution. Biogeographical studies illustrate these changes.	Chapter 15; Chapter 18; Chapter 46	265-266; 326-328; 858-877	**5.D.a:** Use data to evaluate a hypothesis (or prediction), including rejecting or failing to reject the null hypothesis. **5.D.b:** Use data to evaluate a hypothesis (or prediction), including supporting or refuting the alternative hypothesis.	Chapter 46, p. 877, AP Assessment, q. 2, 4, 5
			Illustrative Examples: *• El Niño*	Chapter 46	876		
			• Continental drift.	Chapter 15; Chapter 18	265-266; 326-328		
			• Meteor impact on dinosaurs.	Chapter 18	327-328		