L E A R N I N G O U T C O M E S

UNIT 1: Chemistry of Life

The Chemical Context of Life: Chapter 2	
The three subatomic particles and their significance	
The types of chemical bonds and how they form	
The importance of hydrogen bonding to the properties of water	
Four unique properties of water and how each contribute to life on Earth.	
How to interpret the pH scale	
How changes in pH can alter biological systems.	
The importance of buffers in biological systems.	

Carbon and the Molecular Diversity of Life: Chapter 3	
The properties of carbon that make it so important.	
The role of dehydration reactions in the formation of organic compounds and hydrolysis in the digestion of organic compounds.	
How the sequence and subcomponents of the four groups of organic compounds determine their properties.	
The cellular functions of carbohydrates, lipids, proteins, and nucleic acids.	
How changes in these organic molecules would affect their function.	
The four structural levels of proteins and how changes at any level can affect the activity of the protein.	
How proteins reach their final shape (conformation) the denaturing impact that heat and pH can have on protein structure, and how these changes may affect the organism.	
Directionality influences structure and function of polymers, such as nucleic acids (5’ and 3’ ends) and proteins (amino and carboxyl ends).	

UNIT 2: Cell Structure & Function

A Tour of the Cell: Chapter 4	
Three differences between prokaryotic and eukaryotic cells.	
The structure and function or organelles common to plant and animal cells.	
The structure and function of organelles found only in plant cells or only in animal cells.	
How different cell types show differences in subcellular components.	
How internal membranes and organelles contribute to cell functions.	
How cell size and shape affect the overall rate of nutrient intake and waste elimination.	

Membrane Structure and Function: Chapter 5	
Why membranes are selectively permeable.	
The role of phospholipids, proteins and carbohydrates in the membranes.	
How water will move when a cell is placed in an isotonic, hypertonic, or hypotonic solution and be able to predict the effect of different environments on the organism.	
How electrochemical gradients and protein gradients are formed and function in cells.	

UNIT 3: Cellular Energetics

An Introduction to Metabolism: Chapter 6	
Exergonic reactions release free energy (ΔG is negative); endergonic reactions store free energy (ΔG is positive).	
ATP powers cellular work by coupling exergonic reactions to endergonic reactions	
Enzymes work by lowering the energy of activation.	
The catalytic cycle of an enzyme that results in the production of a final product.	
Enzymes are specific in the reactions they catalyze because of the molecular shape of their active site.	
Factors that change the shape of the active site of enzymes and how they influence enzyme activity.	
How feedback inhibition is used to maintain appropriate levels of enzymes and enzyme products in a pathway.	

Cellular Respiration and Fermentation: Chapter 7	
The summary equation of cellular respiration including the source and fate of the reactants and products.	
The difference between fermentation and cellular respiration.	
The role of glycolysis in oxidizing glucose to two molecules of pyruvate while releasing free energy to form ATP.	
How pyruvate is moved from the cytosol into the mitochondria and introduction into the citric acid cycle.	
How electrons from NADH and $FADH_2$ are passed to a series of electron acceptors to produce ATP by chemiosmosis.	
The roles of the mitochondrial membrane, proton (H^+) gradient, and ATP synthesis in generating ATP.	

Photosynthesis: Chapter 8	
The summary equation of photosynthesis, including the source and fate of the reactants and products.	
How leaf and chloroplast anatomy relate to photosynthesis.	
How photosynthesis convert solar energy to chemical energy.	
How linear electron flow in light reactions results in the formation of ATP, NADPH, and O_2.	
How the formation of a proton gradient in light reactions is used to form ATP, from ADP plus inorganic phosphate by ATP synthase.	
How the Calvin cycle uses the energy molecules of the light reactions (ATP and NADPH) to produce carbohydrates (G3P) from CO_2.	

UNIT 4: Cell Communication & Cell Cycle

Cell Communication: Chapter 5	
The three stages of cell communication: reception, transduction, and response.	
How a receptor protein recognizes signal molecules and starts transduction.	
How a cell signal is amplified by a phosphorylation cascade.	
An example of a second messenger and its role in a signal transduction pathway.	
How a cell response in the nucleus turns on genes, whereas in the cytoplasm a response activates enzymes.	
Why apoptosis is important to normal functioning of multicellular organisms.	

The Cell Cycle: Chapter 9	
The structure of the replicated chromosome.	
The events that occur in interphase of the cell cycle (G1, S, and G2)	
The role of cyclins and cyclin-dependent kinases in the regulation of the cell cycle.	
Ways in which the normal cell cycle is disrupted to cause cancer or halted in certain specialized cells.	
The features of mitosis that result in the production of genetically identical daughter cells including replication, alignment of chromosomes (metaphase) and separtation of chromosomes (anaphase).	

UNIT 5: Heredity

Meiosis and Sexual Life Cycles: Chapter 10	
The difference between asexual and sexual reproduction.	
The role of meiosis and fertilization in passing traits from parents to offspring.	
The importance of homologous chromosomes to meiosis.	
How the chromosome number is reduced from diploid to haploid in meiosis.	
Three events that occur in meiosis but not mitosis.	
The importance of crossing over, independent assortment, and random fertilization to increasing genetic diversity.	

Mendel and the Gene Idea: Chapter 11	
Terms associated with genetics problems: P, F_1, F_2, dominant, recessive, homozygous, heterozygous, phenotype, and genotype.	
How to derive the proper gametes when working a genetics problem.	
The difference between an allele and a gene.	
How to read a pedigree.	
How to use data sets to determine Mendelian patterns of inheritance.	

The Chromosomal Basis of Inheritance: Chapter 12	
How the chromosome theory of inheritance connects the physical movement of chromosomes in meiosis to Mendel's laws of inheritance.	
The unique pattern of inheritance in sex-linked genes.	
How alternation of chromosome number or structurally altered chromosomes (deletion, duplications, etc.) can cause genetic disorders.	
How genomic imprinting and inheritance of mitochondrial DNA are exceptions to standard Mendelian inheritance.	

UNIT 6: Gene Expression

The Molecular Basis of Inheritance: Chapter 13	
The structure of DNA.	
The knowledge about DNA gained from the work of Griffith; Avery, MacLeod, and McCarty; Hershey and Chase; Wilkins and Franklin; and Watson and Crick.	
That replication is semiconservative and occurs 5' to 3'.	
The roles of DNA polymerase, ligase, helicase, and topoisomerase in replication.	
The general difference between bacterial chromosomes and eukaryotic chromosomes.	
How DNA packaging can affect gene expression.	

Gene Expression: From Gene to Protein: Chapter 14	
How RNA and DNA are similar and different and how this defines their roles.	
The difference between replication, transcription, and translation and the role of DNA and RNA in each process.	
How eukaryotic cells modify RNA after transcription.	
How genetic material is translated into polypeptides.	
How mutations can change the amino acid sequence of a protein and be able to predict how a mutation can result in changes in gene expression.	

Regulation of Gene Expression: Chapter 15	
That genes can be activated by inducer molecules or that they can be inhibited by the presence of a repressor as they interact with regulatory proteins or sequences.	
That a regulatory gene is a sequence of DNA that codes for a regulatory protein such as a repressor protein.	
How the components of an operon function to regulate gene expression in both repressible and inducible operons.	
How positive and negative control function in gene expression.	
The impact of DNA methylation and histone acetylation on gene expression.	
How timing and coordination of specific events are regulated in normal development, including pattern formation and induction.	
The role of microRNAs in control of cellular functions.	
The role of gene regulation in embryonic development and cancer.	

DNA Tools and Biotechnology: Concepts 13.4, 15.4, 16.2)	
The terminology of biotechnology.	
How plasmids are used in bacterial transformation to clone genes.	
The key ideas that make polymerase chain reaction (PCR) possible and application of this technology.	
How gel electrophoresis can be used to separate DNA fragments or protein molecules.	
Information that can be determined from DNA gel results, such as fragment size and RFLP analysis.	

Genomes and Their Evolution: Chapter 18	
How prokaryotic genomes compare to eukaryotic genomes.	
Application of bioinformatics to medicine, evolution, and health.	
The activity and role of transposable elements and retrotransposons in generating genetic diversity.	
How evo-devo relates to our understanding of the evolution of genomes.	
The role of homeotic genes and homeoboxes in developmental patterns and sequences.	

UNIT 7: Natural Selection

Descent with Modification: Chapter 19	
Several examples of evidence for evolution from different scientific disciplines and how each supports change of populations over time.	
The difference between structures that are homologous and those that are analogous, and how this relates to evolution.	
The role of adaptations, variation, time, reproductive success, and heritability in evolution.	

Phylogeny and the Tree of Life: Chapter 20	
The taxonomic categories and how they indicate relatedness.	
How systematics is used to develop phylogenetic trees.	
How to construct a phylogenetic tree that represents processes of biological evolution.	
The three domains of life, including their similarities and their differences.	
The significance of widely conserved processes across the three domains.	

The Evolution of Populations: Chapter 21	
Mutations are the only source of new genes.	
The three ways in which sexual reproduction produces genetic variation.	
The conditions for Hardy-Weinberg equilibrium.	
How to use the Hardy-Weinberg equation to calculate allele frequencies to test whether a population is evolving.	
What effects genetic drift, migration, or selection may have on a population, and analyze data to justify your predictions.	

The Origin of Species: Chapter 22	
The biological concept of species.	
Speciation may occur when two populations become reproductively isolated from each other.	
There are prezygotic and postzygotic barriers that maintain reproductive isolation in natural populations.	
How allopatric and sympatric speciation are similar and different.	
How a change in chromosome number can lead to sympatric speciation.	
Why speciation rates are often rapid in situations where adaptive radiation occurs or during times of ecological stress.	
The connection between speciation in an isolated population and a change in gene frequency, a change in the environment, natural selection, and/or genetic drift.	
How punctuated equilibrium and gradualism describe two different tempos of speciation.	

Broad Patterns of Evolution: Chapter 23	
A scientific hypothesis about the origin of life on Earth.	
The age of Earth and when prokaryotic and eukaryotic life emerged.	
Characteristics of the early planet and its atmosphere.	
How Miller and Urey tested the Oparian-Haldane hypothesis and what they learned.	
Methods used to date fossils and rocks and how fossil evidence contributes to our understanding of changes in life on Earth.	
Evidence for endosymbiosis.	
How continental drift can explain the current distribution of species. (biogeography)	
How extinction events open habitats that may result in adaptive radiation.	

UNIT 8: Ecology

An Introduction to Ecology and the Biosphere: Chapter 40	
The role of abiotic factors in the formation of biomes.	
How biotic and abiotic factors affect the distribution of biomes.	
How changes in these factors may alter ecosystems.	
Global climate change is occurring and affects the distribution of organisms.	

Population Ecology: Chapter 40	
How density, dispersion, and demographics can describe a population.	
The differences between exponential and logistic models of population growth.	
How to apply mathematical models to predict changes in population growth rates or size.	
How density-dependent and density-independent factors can control population growth.	
Interactions between populations affect the distributions and abundance of populations.	
How a change in mater or energy will affect the population or community.	
The effect of age distributions and fecundity on human populations as presented in age-structure pyramids.	

Community Ecology: Chapter 41	
The concept of a niche and how it is affected by competition.	
The role of competition exclusion in interspecific competition.	
The symbiotic relationships of parasitism, mutualism, and commensalism.	
Species diversity has two components: species richness and relative abundance.	
The impact of keystone species on community structure.	
The difference between primary and secondary succession.	

Ecosystems and Energy: Chapter 42	
How energy flows through the ecosystem.	
The difference between gross primary productivity and net primary productivity.	
The carbon and nitrogen biogeochemical cycles.	
How biogeochemical cycles affect individual organisms, populations, and ecosystems.	
Energy does not cycle but is lost at each trophic level. A constant input is required. Nutrients do cycle.	

Conservation Biology and Global Change: Chapter 43	
The value of biodiversity and the major human threats to it.	
How human actions are changing the Earth.	
How to predict consequences on both local and global ecosystems of specific human activities.	

UNIT 9: Animal Form and Function

Basic Principles of Animal Form and Function: Chapter 32	
How feedback systems function to maintain homeostasis.	
One example of positive feedback and one example of negative feedback.	

Animal Nutrition: Chapter 33	
A general understanding of digestion paying attention to examples of feedback circuits on page 236.	

Circulation and Gas Exchange: Chapter 34	
Common ancestry and divergence resulting from adaptation in different environments are shown through the different types of respiratory and circulatory systems seen in various animal groups.	
The respiratory and circulatory systems exchange molecules between the environment and the cells. The concepts of diffusion and surface area can explain both anatomy and processes in these two systems.	

The Immune System: Chapter 35	
The roles of innate and adaptive immunity.	
Elements of an innate immune response.	
The differences between B and T cells relative to their activation and actions in adaptive immunity.	
How antigens are recognized by immune system cells.	
How colonial selection explains humoral immunity.	
How T cells function in cell-mediated immunity.	
Why helper T cells are central to immune responses of both B cells and T cells.	

Hormones and the Endocrine System: Chapter 32	
The endocrine system is one of two body systems for communication and regulation.	
How hormones are transported, bind to specific target cells, and trigger cellular responses.	
The secretion, target action, and regulation of at least two hormones.	
An illustration of both positive and negative feedback in the regulation of homeostasis by hormones.	

Animal Reproduction: Chapter 36	
Advantages of asexual reproduction versus sexual reproduction.	
Various reproductive strategies in response to energy availability.	
Timing and coordination or reproduction may be triggered by environmental cues as well as pheromones.	

Animal Development: Chapter 36	
Homeotic genes are involved in developmental patterns and sequences.	
Mutations in critical genes can result in abnormal development.	
Induction of transcription factors during development results in sequential gene expression and the correct timing of events.	
Genetic regulation by microRNAs plays and important role in development.	
Programmed cell death (apoptosis) plays a role in normal development and differentiation (for example, in the morphogenesis of fingers and toes).	
Differentiation in development is a result of cues that trigger gene regulation.	
Different cells receive different signals, resulting in structural and functional divergence.	

Neurons, Synapses and Signaling: Chapter 37	
The anatomy of a neuron.	
The role of active transport in establishing the membrane potential of a neuron.	
The mechanisms of impulse transmission in a neuron.	
How depolarization of the presynaptic cell leads to the release of neurotransmitters.	
The events at the synapse that allow a presynaptic neuron to communicate with the postsynaptic cell.	

Nervous System: Chapter 38	
The brain serves as a master neurological center for processing information and directing responses.	
Different regions of the brain have different functions.	
Structure and associated functions for animal brains are products of evolution, and increasing complexity follows evolutionary lines.	
How the vertebrate brain integrates information, which leads to an appropriate response.	

Sensory and Motor Mechanisms: Chapter 38 and 39	
Different sensory receptors respond to various types of input.	
Neurons communicate with muscle fibers to stimulate contractions.	
Interaction of cellular structures leads to muscle contraction.	

Animal Behavior: Chapter 39	
How behaviors are the result of natural selection.	
Ways in which animals use signals to indicate dominance, find food, establish territory, and ensure reproductive success.	
How innate and learned behaviors increase survival and reproductive fitness.	
How organisms use communication to increase fitness.	
The role of altruism and inclusive fitness in kin selection.	