Introductory Biology I and Lab for Introductory Biology I 2023-2024 Big Ideas, Learning Outcomes, and Assessments

BIG IDEAS

- Structure Relates to Function
- Energy is Transformed in Living Systems
- Genetic Information is Expressed and Transmitted
- Critical Thinking

Big Ideas	Learning Outcomes	Assessments
Unit 0		
Structure Relates to Function	• Recognize that biology is the study of living organisms, including their structure, function, biochemistry, regulatory processes, development and evolution. • Describe the fundamental unit of life, heredity, and processes that drive change in living organisms. • Describe the hierarchy of complexity in biological systems and give examples to illustrate the relationships among different hierarchical levels. • Identify the types of evidence that support the scientific theory that life on earth had a common ancestor and all life forms evolved over a long period of time. • Explain the role of DNA, RNA, ribosomes and proteins in life on Earth.	Quizzes 1 & 2 Learning Module 1 Pre-Lab: Laboratory Safety Post-Lab Conclusion: Laboratory Safety Post-Lab Quiz: Laboratory Safety Unit 0/1 Exam Fall Semester Exam

Big Ideas	Learning Outcomes	Assessments
	• Recognize key features of taxonomic groups of living organisms and be able to classify taxa into domains reflecting their evolutionary history. • Explain the three basic tenets of Cell Theory. • Demonstrate an understanding of the Central Dogma and be able to explain the flow of genetic information within a cell. • Explain how emergent properties of living organisms such as growth and development emerge from and depend upon interactions of elements at different levels of biological organization. • List general rules for working safely in a scientific laboratory. • Explain possible routes of exposure for a hazardous material. • Identify potential situations that could lead to a hazardous event in a laboratory setting. • Identify the locations of emergency equipment (i.e. fire extinguishers, first aid kits, eye wash stations, and fire alarms).	
Unit 1		
Structure Relates to Function	• Understand that models of the atom are used to help understand the properties of elements and compounds, and be able to compare these properties between elements. • Explain the organization of the periodic table and be able to identify trends in groups and periods such as electronegativity.	Learning Modules 2-4 Quizzes 3 & 4 Pre-Lab: Microscope Skills Post-Lab Conclusion: Microscope Skills Post-Lab Quiz: Microscope Skills Unit 0/1 Exam Fall Semester Exam

Big Ideas	Learning Outcomes	Assessments
	• Construct stable biological molecules with the atoms: C, H, O, N, S, and P through intramolecular covalent bonds, and distinguish between polar and nonpolar covalent bonds. • Rank the relative bond strength in hydrogen bonds, ionic bonds, hydrophobic interactions, and van der Waals interactions within and between molecules. Give a specific example for each of these in the context of the cell with aqueous surroundings. • Explain why and which part of a polar molecule can possibly form hydrogen bonds with other polar molecules while those with nonpolar covalent bonds cannot form such H-bonds. • Deduce the concentration of hydrogen ions (H+) and hydroxide ions (OH-) for a given pH and relate the pH scale to the acidy and alkalinity of solutions. Define the role of a buffer system in a biological context with a specific example. • Identify the principal components of a light microscope. • Calculate total magnification for a compound microscope. • Demonstrate the steps to viewing a slide on a microscope. • Measure and calculate the field of view at various magnifications. • Determine the relative depths of microscope specimens.	

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	• Explain how water's capacity for hydrogen bonding accounts for its unique physical properties. Give examples of how these physical properties and water's major role in cellular reactions all support life. • Explain how complex biological molecules are produced from simple monomers by condensation or broken down into simple monomers by hydrolysis. • Recognize the variety of carbon compounds and the properties (polarity, charge) of their distinctive functional groups. • Classify the functional groups as acids and bases. Rank the functional groups in terms of most polar to least polar.	
Unit 2		
Structure Relates to Function	• Recognize the chemical structure of glucose and the glycosidic bond. • Correlate the structures of different carbohydrates with their functions in cells. • Recognize the chemical structures of fatty acids and the ester bond. • Compare the structure and properties of different types of lipids present in cells. • Differentiate the saturated and unsaturated fatty acid components of triglycerides and phospholipids and their corresponding physical and functional properties.	Learning Modules 5-7 Quizzes 5 & 6 Pre-Lab: Biomolecules Post-Lab Conclusion: Biomolecules Post-Lab Quiz: Biomolecules Unit 2 Exam Fall Semester Exam

Big Ideas	Learning Outcomes	Assessments
	• Recognize the chemical structures of nucleotides and the phosphodiester bond. • Compare and contrast the structure and properties of DNA and RNA and tell how their structure relates to their respective functions. • Recognize the chemical structures of amino acids and the peptide bond. • Distinguish four levels of protein structure. Predict how the amino acid sequence in a polypeptide affects the protein's structure and thus its function. • List several ways in which protein structure can be altered by changes in its environment (e.g., temperature, pH). • Understand on a molecular level how certain indicator tests are able to detect lipids, starches, simple carbohydrates, and proteins. • Understand the purpose of positive and negative controls in scientific experiments.	
Unit 3		
Structure Relates to Function	• Develop hypotheses about how molecular interactions under early earth conditions could have led to the formation of ancestral cells and consider possible experiments to test these hypotheses. • Predict properties of a biological molecule that would make it an ideal candidate to be the first molecule of heredity in the pre-biotic world.	Learning Modules 8-10 Quizzes 7 & 8 Pre-Lab: Osmosis and Diffusion Post-Lab Conclusion: Osmosis and Diffusion Post-Lab Quiz: Osmosis and Diffusion Unit 3 Exam Fall Semester Exam

Big Ideas	Learning Outcomes	Assessments
	• Identify the types of evidence that support the scientific theory that life on earth had a common ancestor and all life forms evolved over a long period of time. • Outline appropriate experimental method for observing cells and understanding the functions of various molecules and organelles. • Compare and contrast cell structure, membrane and cell wall biochemistry, and genomic structure in the three domains of life. • Compare and contrast organelles, cell junctions, and cell surface structures in plant and animal cells. • Describe the relationship between structure and function in eukaryotic cell organelles and apply this information to explain the results of experimental manipulations and organelle defects that cause disease. • Given the major function of a particular specialized eukaryotic cell, predict the relative abundance and distribution of its various organelles. • Correlate the structure of different cell membrane components like phospholipids, oligosaccharides, integral and peripheral membrane proteins with their functions. • Predict how changes in membrane composition can affect membrane structure and fluidity. • Outline the pathway by which a newly synthesized polypeptide becomes a functional trans-	

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	membrane protein or is secreted out of the cell, including cell traffic mechanisms. • Compare different modes of transport of molecules across cell membranes with respect to pathway and energy source. • Given the chemical properties of a substance and its relative size, predict how it will cross the membrane. • Predict how transport across membranes is influenced by physical, electrical and chemical factors. • Given an example of differences in solute concentration across a selectively permeable membrane, predict the directionality of net movement of water and the result in plant and animal cells. • Compare different ways in which large molecules are transported in bulk across membranes and elaborate the role of cell structures like receptors in this transport. • Understand the difference between independent and dependent variables in a scientific experiment and how to graph these variables. • Explain different ways cells communicate with each other, contrasting target cell receptors according to their location in the cell and their function. • List the components of signal transduction pathways and tell how they interact to produce specificity and diversity of cell responses.	

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	• Explain possible mechanisms of differential gene expression and molecular responses to extracellular signals that lead to the development of specialized cells in a multicellular organism. • Describe the sequence of events at a chemical synapse that allows a signal to be transmitted from a pre-synaptic cell to a post-synaptic cell. • Tell how signal transduction pathways can cause activation and changes in protein conformation leading to changes in gene expression.	
Unit 4		
Structure Relates to Function	• Recognize the chemical interactions between amino acids and their role in enzyme structure, function and induced fit of the substrate. • On a molecular level, understand how enzymes work. • Describe the effect of an inhibitor on enzyme and substrate activity. • Apply the concepts of free energy, including endergonic vs exergonic reactions and activation energy, to specific examples in biological systems. • Contrast kinetic and potential energy with examples and describe how energy is transferred or transformed in a living system. • Explain why and how ATP is used as an energy molecule by cells and how the energy released from ATP hydrolysis enables cellular work through energy coupling.	Learning Modules 11-13 Quizzes 9 & 10 Fall Semester Exam Pre-Lab: Enzyme Action Post-Lab Conclusion: Enzyme Action Post-Lab Quiz: Enzyme Action

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	• Interpret data showing the effects of substrate concentration, temperature, pH and chemical inhibition on the rate of enzyme-mediated reactions. • Predict how physical factors (like temperature) and chemicals (like pH changes) can affect the rate of the reaction and regulate enzyme function. • Determine the optimal pH and temperature conditions for specific enzyme activity. • Demonstrate the effects of varying substrate concentration on enzyme activity.	
Unit 5		
Energy is Transformed in Living Systems	• Summarize the flow of energy in redox reactions. • State an overview of cellular respiration in terms of the overall redox changes and energy-coupled reactions that occur. • Summarize the net inputs and outputs, and key steps of glycolysis, acetyl CoA formation, citric acid cycle and oxidative phosphorylation. Describe how these stages are linked to each other. • Explain how energy stored in different types of fuel molecules can be released in a series of redox processes to produce ATP by oxidative phosphorylation and substrate-level phosphorylation. • Compare the sites of cellular respiration processes in prokaryotic and eukaryotic cells, and the role of mitochondrial structure in oxidative phosphorylation.	Learning Modules 14-17 Quizzes 11-13 Pre-Lab: Cellular Respiration Post-Lab Conclusion: Cellular Respiration Post-Lab Quiz: Cellular Respiration Unit 5 Exam Pre-Lab: Photosynthesis Post-Lab Conclusion: Photosynthesis Post-Lab Quiz: Photosynthesis Spring Semester Exam

Big Ideas	Learning Outcomes	Assessments
	• Develop a conceptual model predicting how cellular respiration can be regulated in cells. • Predict responses to changing conditions such as lack of oxygen, lack of carbohydrate fuels, or the presence of specific toxins. • Recognize how glycolysis and fermentation function together in the absence of oxygen. • Apply the equation for and processes of cellular respiration in a laboratory setting. • Apply knowledge of temperature effects on enzymes to the process of cellular respiration. • Explain how leaf anatomy, chloroplast structure and photosystem components effectively harvest light energy to produce ATP and NADPH. • Connect how products of the light reactions power carbon dioxide fixation and carbohydrate synthesis in the carbon fixation reactions. • Summarize the chloroplast locations and major inputs and outputs of the light reactions and carbon fixation reactions, and tell how the two major sets of reactions are linked. • Tell how the behavior of the enzyme RuBisCO can limit rates of the carbon fixation reactions in certain conditions. • Compare and contrast mitochondria and chloroplasts in terms of how they are uniquely structured to make ATP during oxidative or photophosphorylation respectively.	

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	• Compare the anatomical and metabolic variations such as C4 and CAM pathways as evolutionary adaptations to improve photosynthetic efficiency. • Relate the cellular processes of fixing CO2 (photosynthesis) and releasing CO2 (respiration) to the broader context of global carbon cycle. • Apply the equation for and processes of photosynthesis in a laboratory setting.	
Unit 6		
Genetic Information is Expressed and Transmitted	• Using a model system example, tell how prokaryotic cell use operons to efficiently regulate initiation of transcription in response to environmental changes. • Compare and contrast positive and negative feedback in gene regulation. • Explain how a eukaryotic cell might regulate the expression of genes through chromosome packing, control sequences, and regulatory proteins. • Explain how two cells with the same genome can contain different proteins. • Compare and contrast the steps at which gene expression can be regulated in eukaryotes and prokaryotes according to the unique requirements of the cell. • When given a DNA sequence, determine the reading frame, identify the template strand and directionality of transcription, and then deduce the sequence of the RNA transcribed.	Learning Modules 18-20 Quizzes 14 & 15 Pre-Lab: DNA Structure Post-Lab Conclusion: DNA Structure Post-Lab Quiz: DNA Structure Unit 6 Exam Spring Semester Exam

Big Ideas	Learning Outcomes	Assessments
	• Name and describe the functions of enzymes, proteins and regulatory DNA sequences required to transcribe a polypeptide-coding gene. • Understand the molecular properties of the cell and DNA that allow DNA to be extracted from a cell. • Describe RNA processing in eukaryotic cells and tell how mRNA splicing might allow a cell to produce multiple different proteins from one gene. • Translate an mRNA sequence with the aid of a universal codon table. • Name and describe the functions of enzymes, proteins, and RNAs required to translate an mRNA at the ribosome. • Compare the processes of transcription and translation between prokaryotic and eukaryotic cells in terms of location, time and cell components. • Predict the effect of various nucleotide base changes on the amino acid sequence and on the resulting polypeptide. • Compare different types of mutations. • Recognize where and how glycosylation, methylation, acetylation, and phosphorylation of proteins occurs.	
Unit 7		

Big Ideas	Learning Outcomes	Assessments
Genetic Information is Expressed and Transmitted	• Outline and interpret the experiments that demonstrated DNA is the molecule of heredity. Understand the concept behind such experiments and predict the results if some of the experiments are modified. • Describe the double helix model of DNA, reviewing the evidence that supports this model. • Elaborate how DNA stores information and how DNA's complementary base pairing determines its function and facilitates replication. • Describe the semi-conservative model of DNA replication and apply it to interpret experiments with labeled nucleotides. • Explain the functions of major enzymes in the process of DNA replication and the 5'-3' specificity of DNA synthesis. • Explain how the anti-parallel arrangement of DNA strands affects the replication process. • Relate the DNA synthesis process with possible repair of mistakes in DNA replication and damages to DNA after DNA is replicated. • Follow the changes in the amount of DNA, structure of chromatin, and structure of cell during the phases of the eukaryotic cell cycle. • Explain how the processes of mitosis and cytokinesis lead to formation of daughter cells with identical genetic information. • Predict the chromosome number of daughter cells when given the chromosome number of parent cells prior to mitosis.	Learning Modules 21-23 Quizzes 16 & 17 Pre-Lab: Mitosis Post-Lab Conclusion: Mitosis Post-Lab Quiz: Mitosis Unit 7 Exam Spring Semester Exam

Big Ideas	Learning Outcomes	Assessments
	• Identify cells in different stages of mitosis in microscopic slides. • Explain how cell cycle control systems and cell cycle checkpoints regulate proper progression through the cell cycle. Tell how a change in one or both of these can lead to cancer. • Predict factors that would influence rate of cell division.	
Unit 8		
Genetic Information is Expressed and Transmitted	• Using the terms alleles and gene loci, describe how genetic variation among individuals is generated by genetic recombination and independent assortment during meiosis. • Apply the concept of homologous chromosomes to explain how normal meiosis reduces the chromosome number. • Distinguish between genotype and phenotype and give examples that relate this distinction to dominant and recessive alleles and to the molecular mechanisms of gene action. • Describe how the inheritance of alleles explains the inheritance of traits. • Describe the contribution of Gregor Mendel and his experiments with pea plants to understanding inheritance. • Replicate Mendel's Laws of Inheritance in a lab experiment. • Differentiate between dominant and recessive traits.	Learning Modules 24-26 Quizzes 18 & 19 Pre-Lab: Inheritance Post Lab Conclusion: Inheritance Post-Lab Quiz: Inheritance Spring Semester Exam

Big Ideas	Learning Outcomes	Assessments
	• Differentiate between a homozygous and heterozygous phenotype. • Predict dominance and inheritance of traits using a Punnett square. • Apply the concept of homologous chromosomes to explain how meiotic errors lead to abnormal chromosome conditions. • Recognize major classes of human trisomy and monosomies.	

Critical Thinking Learning Outcomes:

- Engage in the process of science by practicing observation, generating hypotheses, designing testable experiments, and manipulating data.
- Manipulate numerical data and evaluate the significance of the data using appropriate mathematical and/or statistical methods.
- Use logical reasoning to apply known concepts to novel situations and to identify and evaluate source materials and scholarly literature.
- Demonstrate personal responsibility to set goals and regularly engage in self-assessment of progress towards academic accomplishment.
- Collaborate, discuss, and exchange ideas in a team setting in order to explore creative solutions to complex problems.
- Apply biological concepts to daily life and issues in society.