**UVU BIOL 1610 Course and Specific Learning Outcomes**

Purpose: The purpose of this document is to help guide BIOL 1610 instructors on what topics to cover in the first semester of an introductory biology sequence in college. The course and specific learning outcomes have been established through research on effective teaching strategies, assessment of BIOL 1610 at UVU since 2019, and edited with the help of a BIOL 1610 instructor committee.

The content in BIOL 1610 can be broken down into two levels:

1. The first level is the course learning outcomes.The course learning outcomes are content guidelines so we know what is expected of our students once they successfully complete the course. These course learning outcomes will be assessed in a pre and post semester format through Canvas each semester. Additionally, the course learning outcomes are reported in CourseLeaf for UVU curriculum management. Course learning outcomes do have to be documented in your syllabus. Previous studies have found that some students appreciate knowing the course learning outcomes, but can often be confused by how they are framed and how to use them to study (Brooks et al. , 2014). It might be recommended to take the course learning outcomes and simplify them as an overview on what will be covered in the course as you move through the semester.

1. The second level is the specific learning outcomes. All specific learning outcomes have been mapped under the course learning outcomes. It is recommended that instructors share these with students and use [backward design](https://tll.mit.edu/teaching-resources/course-design/backward-design/#:~:text=Backward%20design%20prioritizes%20the%20intended,you%20begin%20with%20the%20goals.) to implement the specific learning outcomes. Many of these learning outcomes have been adapted from the [nationally endorsed learning outcomes for introductory biology](https://www.biorxiv.org/content/10.1101/2023.10.25.563732v1). **It’s okay for an instructor to modify a specific learning outcome to fit within the framing of their course.** It’s also okay for an instructor to add additional specific learning outcomes they feel are necessary (with a note that less content is more manageable in BIOL 1610).

Lastly, instructors are encouraged to use a recommended [“module” outline and semester schedule](https://docs.google.com/document/d/1qlWjX3vYSynxpv8fLkS5Zp-8AcglN2lPj6024k0z7r8/edit) to structure their BIOL 1610 sections. The goals for all BIOL 1610 sections are to:

1. Teach the essential content for the first semester of an introductory biology sequence that will provide students a rigorous background in science moving forward.
2. Recruit students to a biology-related major/ career path by highlighting career relevancy around content being covered.
3. Engage students through relevancy.

**Terms to know:**

**LOC:** Lower order cognition

**HOC:** Higher order cognition

**CLO #1: Identify the structural components, functions, and relevance of water, carbohydrates, lipids, proteins, and nucleic acids in various biological processes. (Biochemistry)**

Biochemistry

* Identify methyl, hydroxyl, carbonyl, carboxyl, amino, sulfhydryl, and phosphate functional groups. (LOC)
* Distinguish between dehydration and hydrolysis reactions. (LOC)

Water Biochemistry

* Draw the structure of several water molecules that are interacting with other molecules such as NaCl and indicate 1) the electron distributions in each covalent bond, 2) the partial charges on each atom, 3) each hydrogen bond, and (4) describe and identify ionic bonds. (LOC)
* Compare hydrogen bonds and covalent bonds in terms of the mechanisms and strength of attraction between the atoms involved. (LOC)
* Determine if a molecule is hydrophilic, hydrophobic, or amphipathic based on ionic, polar, and non-polar properties. (LOC)
* Label covalent bonds as polar or nonpolar based on the difference in electronegativity between atoms. (LOC)
* Discuss why water is biologically important as an excellent solvent and in terms of high heat capacity, cohesion, and adhesion. (HOC)

Proteins

* Label the four components of an amino acid and explain the role of each in terms of how the molecule functions in a protein. (LOC)
* Describe each of the four levels of protein structure and explain how each influences the protein's final size, shape, and chemical properties. (LOC)
* Describe at least three functions that proteins serve in cells. (LOC)
* Predict whether the R-group on an amino acid that you haven't seen before will interact with water. (HOC)
* Label elements of primary, secondary, tertiary, and quaternary structure on a model of a protein that you haven't seen before. (HOC)
* Fill in the following information for proteins in this table: (HOC)

| Monomer is called | Structure of the monomer | Diagram when two monomers link together | The polymer that is formed is called | The function of the polymer in cells |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |

Nucleic Acids

* Describe at least three functions that nucleic acids serve in cells (LOC)
* Define complementary base pairing, and explain its connection to the observation that DNA strands are antiparallel. (LOC)
* Use the pairing rules to 1) explain the observation that in DNA, %A = %T and %G = %C, 2) predict the sequence of a complementary strand of DNA when given one strand, and 3) calculate the percentage of each base in a DNA molecule when given the percentage of one base. (HOC)
* Discuss the similarities and differences between DNA and RNA based on their structures, chemical composition, location, and functions in the cell. (HOC)
* Label the components and directionality on a model of nucleic acid that you haven’t seen before (HOC)
* Fill in the following information for nucleic acids in this table: (HOC)

| Monomer is called | Structure of the monomer | Diagram when two monomers link together | The polymer that is formed is called | The function of the polymer in cells |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |

Carbohydrates

* Describe at least three functions that carbohydrates serve in cells. (LOC)
* Rank the potential energy in the following bonds from highest to lowest C-C, C-H, C-O and CO. (LOC)
* Discuss how the structure of carbohydrates relate to the use of carbohydrates as energy storage molecules for the cell. (HOC)
* Fill in the following information for carbohydrates in this table: (HOC)

| Monomer is called | Structure of the monomer | Diagram when two monomers link together | The polymer that is formed is called | The function of the polymer in cells |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |

Lipids

* Use drawings, models, or other representations to compare the structures of fats, phospholipids, and steroids (LOC)
* Label the hydrophilic head and hydrophobic tails on a drawing of a phospholipid, then make drawings that include water molecules to explain how phospholipids spontaneously form bilayers in water (LOC)
* Draw the differences between a saturated and unsaturated fatty acid at the carbon bond level. (LOC)
* Given a structural model of a lipid you've never seen before, 1) identify it as a fat, phospholipid, or steroid, 2) determine if it is saturated or unsaturated, and 3) predict its function in the cell. (HOC)
* Given several models of membranes, predict how differences in phospholipid composition and cholesterol content will affect their relative fluidity and permeability, and explain your reasoning. (HOC)

Comparing The Major Classes of Biological Molecules

* Compare the monomer subunit, bond responsible for polymerization, and important biological function(s) observed in proteins, nucleic acids, and carbohydrates. (LOC)
* Compare the primary, secondary, and tertiary structures of proteins, RNA, and DNA. (LOC)
* Analyze how the structure of biological molecules impacts their function, including explaining the connections among the following three statements: 1) amino acids are much more diverse in structure and chemical properties than nucleotides, 2) in terms of diversity in shape and chemical properties, proteins > RNA > DNA, and 3) in terms of diversity in function, proteins > RNA > DNA. (HOC)

Optional to teach/good for instructors to have a solid foundation on

* Define the terms acid, base, and pH. Sketch the pH scale and note where on the scale you find strong acids, strong bases, and neutral solutions. (LOC)
* Explain the relationship between hydrogen bonding and phenomena such as sweating, moderate coastal climates, and the oceans' response to global warming. (HOC)

**CLO #2: Explain how the structure of a cell’s organelles and membrane impacts its function. (Cell Structure and Function)**

Membrane Structure and Transport

* Draw a cell membrane and label integral and peripheral proteins, carbohydrate components, and lipid components. (LOC)
* Compare the processes of diffusion, osmosis, and facilitated diffusion, and provide biological examples that illustrate each process. (LOC)
* Explain why ions and polar molecules do not move across plasma membranes efficiently without a transport protein.(LOC)
* Define passive and active transport and explain the role of channels, carriers, and pumps in transport. (LOC)
* Given several ions and molecules, predict the relative rates at which they will cross a plasma membrane in the absence of membrane proteins. Explain your reasoning. (HOC)

Cell Structure and Organelles

* Compare key elements of prokaryotic versus eukaryotic cell structure. (LOC)
* Compare key elements of plant versus animal cell structure. (LOC)
* Make a flowchart showing how proteins are processed and packaged or unpackaged as they move from ribosomes to the interior of the rough ER to Golgi to motor proteins to their destination. (LOC)
* Compare the structure and function of microtubules, actin filaments (microfilaments), and intermediate filaments. (LOC)
* Propose hypotheses to explain 1) the adaptive significance of organelles (the advantages and disadvantages of having membrane-bound structures inside cells), and 2) why organelles are more common in eukaryotes than bacteria and archaea. (HOC)
* Predict what would happen to a cell if a particular organelle or structure was altered in a specified manner. (HOC)
* Predict the function of a cell when given a drawing of a cell, a micrograph, or a description of a cell's structure and organelle content. Explain your reasoning. (HOC)
* Predict the structure of a cell and its organelle content when given a cell's function. Explain your reasoning. (HOC)
* Predict whether photosynthesis and/or cellular respiration will occur in a specific plant or animal cell, based on information about the cell's structure and function. (HOC)
* Predict what would happen to a particular protein or overall cell function if a specified element or process in the endomembrane system were altered. (HOC)

**CLO #3: Describe how in a cell, genetic information flows and is regulated from DNA to mRNA to proteins. (Genetics)**

DNA Replication

* Describe the function of major components of the replisome: helicase, topoisomerase, DNA polymerase, DNA ligase, and primase. (LOC)
* Use a drawing that you create to explain the statement: "A newly synthesized DNA molecule is half old and half new." (LOC)
* Given a diagram of a DNA molecule during replication, label the following: the origin of replication, directions of replication, replication fork, the leading strand, and lagging strands and their polarities, and the replisome. (LOC)
* Explain how DNA damage and/or mismatches are detected and repaired. (LOC)
* Explain 1) why lagging strand synthesis is an appropriate name, and 2) why Okazaki fragments occur. (HOC)

Central Dogma

* Make a flow chart summarizing the flow of information in cells from gene to protein. Label arrows connecting mRNA, DNA, and proteins, and explain which gene expression process each arrow represents. (LOC)
* Explain how the genetic code relates transcription to translation and why it is considered redundant. (LOC)
* On diagrams of transcription initiation and transcription elongation, label the template and coding strands, initiation complex, promoter site, RNA polymerase, ribonucleotides, the direction of RNA polymerase movement, and direction of RNA synthesis. (LOC)
* On diagrams of translation initiation, translation elongation, and translation termination, label the small and large ribosomal subunits, mRNA, tRNA, rRNA, reading frame, start codon, stop codon, release factor, and tRNA binding sites (E, A, and P). Circle and label the locations where codon- anticodon recognition and peptide bond formation occur. (LOC)
* Add elements to your central dogma model that represent "exceptions" such as 1) production of rRNA, tRNA, and "other RNAs", 2) DNA replication, and 3) the action of an enzyme called reverse transcriptase, which catalyzes the synthesis of DNA from an RNA template. (HOC)
* Given a specific change in a DNA coding strand or a specific error in transcription or translation, predict the consequences for the gene product. (HOC)
* Use a copy of the genetic code to predict the sequence of the amino acids produced from a given mRNA or double stranded DNA fragment. Identify the start and stop codon. (HOC)

Optional to teach/good for instructors to have a solid foundation on

* Explain how negative and positive control over transcription regulates the activity of a given gene or operon. (LOC)
* Using everyday objects like twine or fabric strips, create a model of DNA replication and use it to explain 1) why lagging strand synthesis is an appropriate name, and 2) why Okazaki fragments occur. (HOC)

**CLO #4: Summarize how energy is obtained and transformed through a series of biochemical reactions to perform functions in the cell. (Energetics)**

Enzymatic Reactions

* Explain 1) why "active site" is an appropriate term, 2) the mechanisms responsible for the observation that enzymes lower activation energies, 3) why most enzymes catalyze one specific reaction, and 4) why enzymes increase reaction rates but do not make endergonic reactions exergonic. (LOC)
* Explain 1) the general role of ATP in the cell, 2) what it means to say that two chemical reactions are coupled, and 3) why a large change in free energy level occurs when an enzyme or substrate is phosphorylated. (Recall that phosphorylation adds 3 tightly packed negative charges.) (LOC)
* Distinguish between competitive inhibition and noncompetitive inhibition. (LOC)
* Explain how enzyme activity can be regulated by cofactors and coenzymes. (LOC)
* Explain how physical factors affect enzyme structure and reaction rate. (LOC)
* Explain how feedback inhibition regulates metabolic pathways. (HOC)

Photosynthesis

* Describe how chlorophyll molecules harvest light energy and transfer energy. (LOC)
* Explain the relationship between the light-dependent reactions and the Calvin cycle. (LOC)
* Make a chart summarizing the inputs and outputs of PSI, PSII, and the Calvin cycle using NADPH, Glucose, H2O, O2, CO2, H+ gradients, and ATP. Using this chart, explain the energy transformations that occur and the role of rubisco. (LOC)
* Explain to a non-scientist how the CO2 in "weightless" air is the source of mass in a redwood tree. (HOC)
* Predict the possible consequences for the production of ATP and NADPH if a component or process in the photosynthesis pathway is altered. (HOC)

Cellular Respiration

* Make a chart summarizing the inputs and outputs of glycolysis, pyruvate processing, the citric acid cycle, and oxidative phosphorylation, using NADH, FADH2, Glucose, Acetyl CoA, Pyruvate, O2, CO2, H+ gradients, and ATP. Using the chart, explain how energy is transferred or transformed in each stage. (LOC)
* Explain how cells use fermentation pathways to obtain energy from glucose in the absence of oxygen. (LOC)
* Predict the possible consequences if a step in the glucose oxidation (cellular respiration) pathway is altered. (HOC)
* Predict the effects of altering specific parts of the electron transport chain or ATP synthase. (HOC)

Overall

* Distinguish between catabolic and anabolic reactions
* Given the summary reactions for photosynthesis and respiration, compare 1) the reactants and products of each process, and 2) the energy transformations that occur. (LOC)

Optional to teach/good for instructors to have a solid foundation on

* Interpret graphs of reaction rate versus pH, temperature, and degree of substrate saturation for a given enzyme. Based on your analysis, predict the nature of the cell's normal environment in nature. (HOC)
* Given graphs showing how free energy changes over the course of a chemical reaction, predict whether two specific reactions can be successfully coupled. (HOC)

**CLO#5: Discuss the molecular mechanisms responsible for generating mutations and the impact of those mutations on genetic variation in populations (Evolution/Genetics)**

* Rank the following mutations in terms of greatest to least impact on the structure and function of genes and gene products: missense (change amino acids), nonsense (change to "stop"), frameshift (change reading frame), and silent (no change in the product). Explain your reasoning. (HOC)
* Defend the statement "mutation is the ultimate source of genetic variation," and explain why mutation is random with respect to its impact on an individual's fitness. (HOC)
* Explain why cancer is 1) associated with mutations that regulate the cell cycle, and 2) more common in older than younger people. (HOC)

**CLO #6: Describe how new alleles resulting from mutations can be inherited through the processes of mitosis, meiosis, and cell division (Evolution/Genetics)**

Mitosis

* Explain why chromosome replication has to occur before mitosis, in interphase. (LOC)
* Diagram the sequence of stages in the eukaryotic cell cycle (M, G1, S, and G2) and label the major event or events that occur in each. (LOC)
* Given a labeled drawing showing the phases of mitosis, explain what is happening to the chromosomes and how it helps ensure that each daughter cell gets a complete and identical set. (HOC)
* Given a micrograph or drawing of a cell you've never seen before, label the chromosomes, chromatids, sister chromatids, and homologous chromosomes, if present, and determine the haploid number and ploidy. (HOC)
* Given a micrograph or drawing of a cell you've never seen before that is undergoing mitosis, explain what is currently happening to the chromosomes. (HOC)
* Predict the consequences of altering a given stage (M, G1, S, and G2) in the cell cycle in terms of the cell's structure or fate. (HOC)

Meiosis

* Explain the differences between somatic cells and germ cells. Describe the outcomes of cell division between these two categories of cells. (LOC)
* Explain why chromosome replication has to occur before meiosis, in interphase. (LOC)
* Differentiate between the genetic information held on two homologous chromosomes, two nonhomologous chromosomes, two sister chromatids, and two non-sister chromatids. (LOC)
* Explain why the segregation of homologous chromosomes in meiosis I leads to a reduction in ploidy. (LOC)
* Explain why no two haploid cells that result from meiosis are alike in terms of genotype and why this is important in terms of offspring fitness. (LOC)
* Given a micrograph or drawing of a cell you've never seen before that is undergoing meiosis, explain what is currently happening to the chromosomes.(HOC)
* Given a specific error in meiosis, predict the haploid genotypes that result and discuss the consequences for offspring.(HOC)

**CLO #7: Extract information about genes, alleles, and gene functions from genetic crosses and human pedigree analysis. (Evolution/Genetics)**

* Set up Punnett squares for monohybrid crosses and dihybrid crosses. Label which elements in the Punnett square and dihybrid cross represent the genotypes of egg, sperm, and offspring. Explain how you can determine the frequency of each egg and sperm genotype and how you can use this information to calculate the frequencies of offspring genotypes and phenotypes. (LOC)
* Define polygenic inheritance and explain why it produces traits with a continuous variation. (LOC)
* Using a drawing that shows the phases of meiosis, label the events that explain Mendel's principles of segregation and independent assortment. Add drawings to show how independent assortment can generate genetic variation in offspring. In each case, explain your reasoning. (LOC)
* On a pedigree, label 1) genetic males and females, 2) affected and unaffected individuals, and 3) generations. (LOC)
* Given information on parental and offspring phenotypes, determine whether the dominance system involved is 1) in a complete dominance, codominance, or incomplete dominance system and 2) if it is an autosomal or sex-linked trait. (HOC)
* Based on the data in a pedigree, predict 1) whether the trait in question is autosomal or sex-linked and 2) which alleles are dominant and recessive. (HOC)

**CLO #8: Apply evidence-based reasoning and biological knowledge to inform health, environmental, and/or societal related decisions.**

\*Ideally every unit/module will have a storyline that ties this CLO in. Potential topics to include in BIOL 1610 are:

* Climate change (water biochemistry)
* Vaccination (influenza mutations/ impact of mutations on protein structure and function)
* GMOs
* Cancer
* Evolution acceptance
* Use of genome to categorize people
* Myth of race as a biological construct
* Hidden figures in science (Rosalind Franklin, Martha Chase, Vivien Thomas)
* Biological sex as a spectrum (gene regulation, meiosis)
* Antibiotic resistance
* Career opportunities and salary associated with careers