Biology at Argo Community High School

Updated 2022

ARGO COMMUNITY HIGH SCHOOL

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Semester One

Unit 0: Introduction to Biology Basics

This pre-unit is for students to get the science basics that can then be applied to activities and labs for the rest of the year, as well as in their future science courses. Students learn how to write a hypothesis using the 'if/then/because' format, recognize a well-designed experiment by identifying independent, dependent and control variables, name lab equipment used in an experiment, and organize data and chose the appropriate graph type to display information.

TOPIC 0.1 Lab Equipment

Learning Objective

Identify the different types of lab equipment used in a science classroom.

Essential Knowledge

- Know the names of the different types of glassware and what they are used for
- Know the names of other lab equipment that is not glassware
- Take proper measurements and know the units for the measurements done with a specific piece of lab equipment

TOPIC 0.2 Designing and Conducting an Experiment

Learning Objective

Recognize and design a well-designed experiment

Essential Knowledge

- Write a hypothesis using the if/then/because format
- Identify independent, dependent and control variables of an experiment
- List the general steps of the scientific method

TOPIC 0.3 Organizing and Interpreting Data

Learning Objective

Organize data collected in lab by creating a data table, graph and drawing conclusions from data collected

Essential Knowledge

- Produce the correct type of graph needed to create a visual representation of the data collected
- Produce a CER response

Unit 1: Chemistry of Life (biochemistry)

This first unit sets the foundation for students to understand the chemical basis of life, which is needed for mastery of future areas of focus and provides students with a survey of the elements necessary for carbon-based systems to function. Students learn that water and the properties of water play a vital role in the survival of individuals and biological systems.
They also learn that living systems exist in a highly complex organization that requires input of energy and the exchange of macromolecules. This unit also addresses in detail how and in what conformations molecules called monomers bond together to form polymers. The structure of monomers and polymers determines their function. In the units that follow, students will need to understand and explain the interaction and bonding of atoms to form molecules.

TOPIC 1.1 Structure of Water and Hydrogen Bonding

Learning Objective

Explain how the properties of water that result from its polarity and hydrogen bonding affect its biological function

Essential Knowledge

- The subcomponents of biological molecules and their sequence determine the properties of that molecule.
- Living systems depend on properties of water that result from its polarity and hydrogen bonding.
- The hydrogen bonds between water molecules result in cohesion, adhesion, and surface tension.

TOPIC 1.2 Elements of Life

Learning Objective

Describe the composition of macromolecules required by living organisms

Essential Knowledge

- List the six elements necessary for life
    - 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.
    - Nitrogen is used to build proteins and nucleic acids. Phosphorus is used to build nucleic acids and certain lipids.
- Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.
    - List the levels of organization of that make up an organism, starting with an atom and ending with an organism.
- Atoms and molecules from the environment are necessary to build new molecules

TOPIC 1.3 Properties of Biological Macromolecules

Learning Objective

Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules

Essential Knowledge

Structure and function of polymers are derived from the way their monomers are assembled—

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.
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.
c. Complex carbohydrates comprise sugar monomers whose structures determine the properties and functions of the molecules.
d. Lipids are nonpolar macromolecules—
    i. Phospholipids contain polar regions that interact with other polar molecules, such as water, and with nonpolar regions that are often hydrophobic.
e. Hydrolysis and dehydration synthesis are used to cleave and form covalent bonds between monomers.

Unit 2: Cell Structure and Function

The cell is the basic unit of life. Cells contribute to the organization of life and provide the environment in which organelles function. Organelles in turn provide compartmentalization and organize cellular products for dispersal and waste for disposal. Cells have membranes that allow them to establish and maintain an internal environment. These membranes also control the exchange of material with the cell's external environment—an important, foundational concept. The maintenance of the internal and external conditions of a cell is called homeostasis. Student understanding of these concepts will be necessary in later units when the focus of instruction shifts to cellular products and by-products and when students learn why cellular exchange of energy and materials matters.

TOPIC 2.1: Cell Theory and Types of Cells

Learning Objective

- Summarize the three principles of cell theory
- Differentiate between prokaryotes and eukaryotes

Essential Knowledge

- All living organisms are composed of one or more cells, cells are the basic structural and functional unit of all living organisms, all cells arise from pre-existing cells.
- Prokaryotes do not have a membrane-bound nucleus and eukaryotes do, along with other differences like cell size, unicellular compared to multicellular, DNA structure, and common features such as ribosomes, cell membrane, cytoplasm, DNA.

TOPIC 2.2: Cell Structure: Subcellular Components

Enduring Understanding

- Living systems are organized in a hierarchy of structural levels that interact.

Learning Objective

Describe the structure and/or function of organelles

Essential Knowledge

- Nucleus
- Cytoplasm
- Nucleolus
- Ribosomes
- Endoplasmic reticulum (rough and smooth)
- Golgi complex
- Mitochondria
- Lysosomes
- Vacuole
- Chloroplasts
- Cell Membrane

TOPIC 2.3: Cell/Plasma Membranes

Enduring Understanding

Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.

Learning Objective

Describe the roles of each of the components of the cell membrane in maintaining the internal environment of the cell and describe the fluid mosaic model

Essential Knowledge

- 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.

- Embedded proteins can be hydrophilic, with charged and polar side groups, or hydrophobic, with nonpolar side groups.

TOPIC 2.4: Membrane Permeability

Enduring Understanding
Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.

Learning Objective
Explain how the structure of biological membranes influences selectively permeability (semi-permeable).

Essential Knowledge
- The structure of cell membranes results in selective permeability.
- Cell membranes separate the internal environment of the cell from the external environment.
- Selective permeability is a direct consequence of membrane structure, as described by the fluid mosaic model.
- 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.
- Polar uncharged molecules, including H_2O, pass through the membrane in small amounts.

Learning Objective
Describe the role of the cell wall in maintaining cell structure and function.

Essential Knowledge
- Cell walls provide a structural boundary, as well as a permeability barrier for some substances to the internal environments.
- Cell walls of plants, prokaryotes, and fungi are composed of complex carbohydrates.

TOPIC 2.5: Microscope

Learning Objective
Be able to use a light compound microscope to view different biological specimens

Essential Knowledge
- Name the parts of the microscope and their functions
- Be able to focus biological specimens by making a wet mount slide or using a prepared slide
- Identify a cell's nucleus, cytoplasm, cell membrane and cell wall (if a plant)

TOPIC 2.6: Membrane Transport

Enduring Understanding
Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.

Learning Objective
- Describe the mechanisms that organisms use to maintain solute and water balance.
- Passive transport is the net movement of molecules from high concentration to low concentration without the direct input of metabolic energy.
- Passive transport plays a primary role in the import of materials and the export of wastes.
- Active transport requires the direct input of energy to move molecules from regions of low concentration to regions of high concentration.

Learning Objective
Describe the mechanisms that organisms use to transport large molecules across the plasma membrane.

Essential Knowledge
- The selective permeability of membranes allows for the formation of concentration gradients of solutes across the membrane.
- The processes of endocytosis and exocytosis require energy to move large molecules into and out of cells—
  a. In exocytosis, internal vesicles fuse with the plasma membrane and secrete large macromolecules out of the cell.

b. In endocytosis, the cell takes in macromolecules and particulate matter by forming new vesicles derived from the plasma membrane.

TOPIC 2.7: Facilitated Diffusion

Enduring Understanding

Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.

Learning Objective

- Explain how the structure of a molecule affects its ability to pass through the plasma membrane.

Essential Knowledge

- Membrane proteins are required for facilitated diffusion of charged and large polar molecules through a membrane—
  a. Large quantities of water pass through aquaporins.
  b. Charged ions, including Na^+ and K^+, require channel proteins to move through the membrane.
  c. Membranes may become polarized by movement of ions across the membrane.
- Membrane proteins are necessary for active transport.
- 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.

UNIT 3: Cell Cycle

In Unit 3, students continue to learn about the role of cells, focusing on how cells use energy and information transmission to communicate and replicate. Cells can also generate and receive signals, coordinate mechanisms for growth, and respond to environmental cues. To maintain homeostasis, cells respond to their environment. They can also replicate and regulate replication as part of the cell cycle that provides for the continuity of life.

TOPIC 3.1: Cell Cycle and Division

Enduring Understanding

Heritable information provides for continuity of life.

Learning Objective

Describe the events that occur in the cell cycle.

Essential Knowledge

- In eukaryotes, cells divide and transmit genetic information via two highly regulated processes.

Essential Knowledge

The cell cycle is a highly regulated series of events for the growth and reproduction of cells—

a. The cell cycle consists of sequential stages of interphase (G1, S, G2), mitosis, and cytokinesis.
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.

Learning Objective

Explain how mitosis results in the transmission of chromosomes from one generation to the next.

Essential Knowledge

Mitosis is a process that ensures the transfer of a complete genome from a parent cell to two genetically identical daughter cells—

a. Mitosis plays a role in growth, tissue repair, and asexual reproduction.
b. Mitosis alternates with interphase in the cell cycle.
c. Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase).

TOPIC 3.2: Regulation of Cell Cycle

Enduring Understanding

Heritable information provides for continuity of life.

Learning Objective

Describe the role of checkpoints in regulating the cell cycle.

Essential Knowledge

- A number of internal controls or checkpoints regulate progression through the cycle.

Learning Objective

Describe the effects of disruptions to the cell cycle on the cell or organism.

Essential Knowledge

- Disruptions to the cell cycle may result in cancer and/or programmed cell death (apoptosis).

UNIT 4: Energy Flow

Living systems are complex in their organization and require constant energy input. This unit will provide students with the knowledge necessary to master the concepts of energy capture and use. Students work through enzyme structure and function, learning the ways in which the environment plays a role in how enzymes perform their function(s). Students gain a deeper understanding of the processes of photosynthesis and cellular respiration.

Enduring Understanding

The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.

TOPIC 4.1: ATP

Learning Objective

Describe the role of energy in living organisms.

Essential Knowledge

- All living systems require constant input of energy.
- 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.
  b. Cellular processes that release energy may be coupled with cellular processes that require energy.
  c. Loss of order or energy flow results in death.

TOPIC 4.2: Transfer of Energy

Learning Objective

Explain where organisms get the energy they need to function.

Essential Knowledge

- Autotrophs capture energy from physical or chemical sources in the environment—
  a. Photosynthetic organisms capture energy present in sunlight.
- Heterotrophs capture energy present in carbon compounds produced by other organisms.
  a. Heterotrophs may metabolize carbohydrates, lipids, and proteins as sources of energy by hydrolysis.

TOPIC 4.3: Photosynthesis

Learning Objective

Describe the photosynthetic processes that allow organisms to capture and store energy.

Essential Knowledge

- Organisms capture and store energy for use in biological processes—
  a. Photosynthesis captures energy from the sun and produces sugars.
  b. 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. These products power the production of carbohydrates from carbon dioxide in the Calvin cycle (light independent reactions).
  c. The reaction is endothermic. The reactants for the net equation include carbon dioxide and water, and the products are glucose and oxygen gas.

TOPIC 4.4: Cellular Respiration

Learning Objective

Describe the processes that allow organisms to use energy stored in biological macromolecules.

Essential Knowledge

- Cellular respiration use energy from biological macromolecules to produce ATP. Respiration is a characteristic of all forms of life.

- Cellular respiration in eukaryotes involves a series of coordinated enzyme-catalyzed reactions (glycolysis, Krebs cycle, ETC) that capture energy from biological macromolecules.
- The reaction is exothermic. The reactants for the net equation include glucose and oxygen gas, and the products are carbon dioxide and water.

TOPIC 4.5: Enzymes

Learning Objective

Describe the properties of enzymes.

Essential Knowledge

- The structure of enzymes includes the active site that specifically interacts with substrate molecules.
- 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.

Learning Objective

Explain how enzymes affect the rate of biological reactions.

Essential Knowledge

- 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.

Learning Objective

Explain how changes to the structure of an enzyme may affect its function. Explain how the cellular environment affects enzyme activity.

Essential Knowledge

- 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—
  a. Denaturation of an enzyme occurs when the protein structure is disrupted, eliminating the ability to catalyze reactions.
  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.

Unit 5: DNA Replication and Protein Synthesis

In unit 5 students gain knowledge about nucleic acids and their role in gene expression. Students gain an understanding of how DNA is replicated and the differences between DNA and RNA. Genetic information flows from DNA to RNA to protein. Understanding protein synthesis (transcription and translation) is vital to answering essential questions about gene expression.

Enduring Understanding

Heritable information provides for continuity of life.

TOPIC 5.1: DNA structure

Learning Objective

Describe the characteristics of DNA that allow it to be used as the hereditary material.

Essential Knowledge

- DNA is the primary source of heritable information. Genetic information is transmitted from one generation to the next through DNA
- DNA 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)—
  a. Purines (G and A) have a double ring structure.
  b. Pyrimidines (C, T, and U) have a single ring structure.

TOPIC 5.2: DNA Replication

Learning Objective

Describe the mechanisms by which genetic information is copied for transmission between generations.

Essential Knowledge

- 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. DNA polymerase requires RNA primers to initiate DNA synthesis.
  e. DNA polymerase synthesizes new strands of DNA continuously on the leading strand and discontinuously on the lagging strand.
  f. Ligase joins the fragments on the lagging strand.

Semester Two

TOPIC 5.3: Comparing DNA and RNA

Learning Objective

Describe the structural similarities and differences between DNA and RNA.

Essential Knowledge

- DNA and RNA molecules have structural similarities and differences related to their function—
  a. 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.

TOPIC 5.4: Transcription and RNA Processing

Learning Objective

Describe the mechanisms by which genetic information flows from DNA to RNA to protein.

Essential Knowledge

- The sequence of the RNA bases, together with the structure of the RNA molecule, determines RNA function—
  a. mRNA molecules carry information from DNA to the ribosome.
  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.
  c. rRNA molecules are functional building blocks of ribosomes.
- 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.
- 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
- In eukaryotic cells the mRNA transcript undergoes a series of enzyme-regulated modifications prior to leaving the nucleus.

TOPIC 5.5: Translation

Learning Objective

Describe the mechanisms by which genetic information flows from DNA to RNA to protein.

Essential Knowledge

- 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. In prokaryotic organisms, translation of the mRNA molecule occurs while it is being transcribed.

TOPIC 5.6: Mutations

Learning Objective

Describe the various types of gene mutations (point and frameshift).

Essential Knowledge

- Errors in DNA replication or DNA repair mechanisms, and external factors, including radiation and reactive chemicals, can cause random mutations in the DNA.

- Changes in the genetic code can impact the product produced in protein synthesis
  a. 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.

UNIT 6: Genetics

Unit 6 focuses on heredity and the biological concepts and processes involved in ensuring the continuity of life. Students learn that the storage and transmission of genetic information via chromosomes from one generation to the next occur through meiosis. Meiotic division ensures genetic diversity, which is crucial to the survival of a species. In this unit, students gain a deeper understanding of Mendelian genetics and learning how non-Mendelian genetics describes those patterns of inheritance that seem to violate Mendel's laws. This unit also teaches the role played by chromosomal inheritance, environmental factors, and nondisjunction on an individual's phenotype.

TOPIC 6.1: Meiosis

Enduring Understanding

Heritable information provides for continuity of life.

Learning Objective

Explain how meiosis results in the transmission of chromosomes from one generation to the next.

Essential Knowledge

- Meiosis is a process that ensures the formation of haploid gamete cells in sexually reproducing diploid organisms—
  a. Meiosis results in daughter cells with half the number of chromosomes of the parent cell.
  b. Meiosis involves two rounds of a sequential series of steps (meiosis I and meiosis II).

Learning Objective

Describe similarities and/ or differences between the phases and outcomes of mitosis and meiosis.

Essential Knowledge

- 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.
- 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.

TOPIC 6.2: Mendelian Genetics

Learning Objective

Explain the inheritance of genes and traits as described by Mendel's laws and understand the use of Punnett squares in predicting genotype/phenotype probabilities.

Essential Knowledge

- Mendel's laws of segregation and independent assortment can be applied to genes that are on different chromosomes.
- 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—
  a. Rules of probability can be applied to analyze passage of single-gene traits from parent to offspring.
  b. The pattern of inheritance (monohybrid, dihybrid, sex-linked) can often be predicted from data, including pedigree, that give the parent genotype/phenotype and the offspring genotypes/phenotypes.

TOPIC 6.3: Non-Mendelian Genetics

Enduring Understanding

Heritable information provides for continuity of life

Learning Objective

Explain deviations from Mendel's model of the inheritance of traits.

Essential Knowledge

- Many traits are the product of multiple genes and/or physiological processes acting in combination; these traits therefore do not segregate in Mendelian patterns.
- Sex- linked traits

- Incomplete dominance
- Codominance (including blood types)
- Environmental factors can influence gene expression

TOPIC 6.4: Variation and Mutation

Enduring Understanding

Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Learning Objective

Explain how chromosomal inheritance generates genetic variation in sexual reproduction.

Essential Knowledge

- Segregation, independent assortment of chromosomes, and fertilization result in genetic variation in populations.
- The chromosomal basis of inheritance provides an understanding of the pattern of transmission of genes from parent to offspring.
- Certain human genetic disorders can be attributed to the inheritance of a single affected or mutated allele or specific chromosomal changes, such as nondisjunction.
- Whether a mutation is detrimental, beneficial, or neutral depends on the environmental context.
- Mutations are the primary source of genetic variation.
- Errors in mitosis or meiosis can result in changes in phenotype—
  a. Changes in chromosome number often result in human disorders with developmental limitations, including Down syndrome/ Trisomy 21 and Turner syndrome.
  b. Karyotype analysis can be used to identify disorders

Unit 7: Evolution

The concepts in Unit 7 build on foundational content from previous units as students discover natural selection, a mechanism of evolution—the theory that populations that are better adapted to their environment will survive and reproduce. Thus, the evolution of a species involves a change in its genetic makeup over time. In this unit, students study the evidence for and mechanisms of evolutionary change. *(Students also learn what happens when a species does not adapt to a changing or volatile environment and about the Hardy-Weinberg equilibrium as a model for describing and predicting allele frequencies in nonevolving populations. Students will learn to calculate and draw conclusions about the evolution, or lack thereof, of a population from data related to allele frequencies.)* Biological principles studied here and in previous units will culminate in Unit 8, which covers ecology.

TOPIC 7.1: Natural Selection

Enduring Understanding

Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.

Learning Objective

Explain the interaction between the environment and random or preexisting variations in populations.

Essential Knowledge

- 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.
- Mutations are random and are not directed by specific environmental pressures.

Learning Objective

Describe the causes of natural selection and describe the importance of phenotypic variation in a population.

Essential Knowledge

- Natural selection is a major mechanism of evolution.
- 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.
- Natural selection acts on phenotypic variations in populations.
- Environments change and apply selective pressures to populations.
- Some phenotypic variations significantly increase or decrease fitness of the organism in particular environments.
- Evolutionary fitness is measured by reproductive success.
- Convergent evolution occurs when similar selective pressures result in similar phenotypic adaptations in different populations or species.

Learning Objective

Describe the conditions under which new species may arise.

Essential Knowledge

- Speciation may occur when two populations become reproductively isolated from each other.
- 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.

Learning Objective

Describe the rate of evolution and speciation under different ecological conditions.

Essential Knowledge

- 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.
- 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.

TOPIC 7.3: Artificial Selection

Learning Objective
Explain how humans can affect diversity within a population.

Essential Knowledge
- Through artificial selection, humans affect variation in other species.

TOPIC 7.4: Population Genetics

Learning Objective
Explain how random occurrences affect the genetic makeup of a population.

Essential Knowledge
- Evolution is also driven by random occurrences—
  a. Mutation is a random process that contributes to evolution.
  b. Genetic drift is a nonselective process occurring in small populations—
     i. Bottlenecks.
     ii. Founder effect.
  c. Migration/gene flow can drive evolution

TOPIC 7.5: Hardy-Weinberg Equilibrium

Enduring Understanding
Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.

Learning Objective
Describe the conditions under which allele and genotype frequencies will change in populations.

Essential Knowledge
- *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.*
- *Allele frequencies in a population can be calculated from genotype frequencies.*

Relevant Equations:

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

Learning Objective
Explain the impacts on the population if any of the conditions of Hardy- Weinberg are not met.

Essential Knowledge
- *Changes in allele frequencies provide evidence for the occurrence of evolution in a population.*
- *Small populations are more susceptible to random environmental impact than large populations.*

If time allows.

TOPIC 7.6: Evidence of Evolution

Learning Objective
Describe the types of data that provide evidence for evolution.

Essential Knowledge
- Evolution is supported by scientific evidence from many disciplines (geographical, geological, physical, biochemical, and mathematical data).

Learning Objective
Explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time.

Essential Knowledge
- Molecular, morphological, and genetic evidence from extant and extinct organisms adds to our understanding of evolution—
  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
  b. Morphological homologies, including vestigial structures, represent features shared by common ancestry.
- A comparison of DNA nucleotide sequences and/or protein amino acid sequences provides evidence for evolution and common ancestry.

Learning Objective
Organisms are linked by lines of descent from common ancestry. Describe the fundamental molecular and cellular features shared across all domains of life, which provide evidence of common ancestry.

Essential Knowledge
- Many fundamental molecular and cellular features and processes are conserved across organisms.
- Structural and functional evidence supports the relatedness of organisms in all domains.
- DNA and RNA are carriers of genetic information.
- Ribosomes are found in all forms of life.
- Major features of the genetic code are shared by all modern living systems.
- Core metabolic pathways are conserved across all currently recognized domains.

TOPIC 7.7: Phylogeny

Learning Objective
Describe the types of evidence that can be used to infer an evolutionary relationship.

Essential Knowledge
- Phylogenetic trees and cladograms show evolutionary relationships among lineages—
  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.
  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 out-group represents the lineage that is least closely related to the remainder of the organisms in the phylogenetic tree or cladogram.
  c. Molecular data typically provide more accurate and reliable evidence than morphological traits in the construction of phylogenetic trees or cladograms.

Learning Objective
Explain how a phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness

Essential Knowledge
- 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.

- Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species and from DNA and protein sequence similarities.
- Phylogenetic trees and cladograms represent hypotheses and are constantly being revised, based on evidence.

TOPIC 7.8: Extinction

Learning Objective

Describe factors that lead to the extinction of a population

Essential Knowledge

- Extinctions have occurred throughout Earth's history.
- Extinction rates can be rapid during times of ecological stress.
- Human activity can drive changes in ecosystems that cause extinctions.

Unit 8: Ecology

As a culmination of this course, Unit 8 brings together all other units to show how a system's interactions are directly related to the system's available energy and its ability to evolve and respond to changes in its environment. When highly complex living systems interact, communities and ecosystems will change based on those interactions. The more biodiversity present in a system, the more likely that system is to maintain its health and success in the face of disruption. Energy flows through systems; the rate of flow determines the success of the species within the systems. By this point in the curriculum, a student should be able to accurately determine what happens within biological systems when disruptions occur.

TOPIC 8.1: Energy Flow Through Ecosystems

Enduring Understanding

The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.

Learning Objective

Describe the strategies organisms use to acquire and use energy.

Essential Knowledge

- Organisms use energy to maintain organization, grow, and reproduce—
  a. Organisms use different strategies to regulate body temperature and metabolism.
  b. Different organisms use various reproductive strategies in response to energy availability.

Learning Objective

Explain how changes in energy availability affect populations and ecosystems.

Essential Knowledge

- Changes in energy availability can result in changes in population size.
- Changes in energy availability can result in disruptions to an ecosystem—
  a. A change in energy resources such as sunlight can affect the number and size of the trophic levels.
  b. A change in the producer level can affect the number and size of other trophic levels.
  c. A food web is a model of an interlocking pattern of food chains that depicts the f low of energy and nutrients in two or more food chains.
  d. When one species is removed from or added to a specific food web, the rest of the food web can be affected.

Learning Objective

Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem.

Essential Knowledge

- Autotrophs capture energy from physical or chemical sources in the environment—
  a. Photosynthetic organisms capture energy present in sunlight.
- Heterotrophs capture energy present in carbon compounds produced by other organisms.
  b.Heterotrophs may metabolize carbohydrates, lipids, and proteins as sources of energy by hydrolysis.

TOPIC 8.2: Population Ecology

Learning Objective

Describe factors that influence growth dynamics of populations.

Essential Knowledge

- Populations comprise individual organisms that interact with one another and with the environment in complex ways.
- Many adaptations in organisms are related to obtaining and using energy and matter in a particular environment—
  a. Population growth dynamics depend on a number of factors, such as birth rate, death rate, immigration, emigration.
  b. Reproduction without constraints results in the exponential growth of a population.

Learning Objective

Explain how the density of a population affects and is determined by resource availability in the environment.

Essential Knowledge

- A population can produce a density of individuals that exceeds the system's resource availability.
- As limits to growth due to density-dependent and density-independent factors are imposed, a logistic growth model generally ensues

TOPIC 8.3: Community Ecology

Enduring Understanding

Communities and ecosystems change on the basis of interactions among populations and disruptions to the environment.

Learning Objective

Describe the structure of a community according to its species composition and diversity.

Essential Knowledge

- The structure of a community is measured and described in terms of species composition and species diversity.

Learning Objective

Explain how interactions within and among populations influence community structure.

Essential Knowledge

- Communities change over time depending on interactions between populations.
- Interactions among populations determine how they access energy and matter within a community.
- 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.
- Competition, predation, and symbioses, including parasitism, mutualism, and commensalism, can drive population dynamics.

Learning Objective

Explain how community structure is related to energy availability in the environment.

Essential Knowledge

Cooperation or coordination between organisms, populations, and species can result in enhanced movement of, or access to, matter and energy.

TOPIC 8.6: Biodiversity

Enduring Understanding

Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Learning Objective

Describe the relationship between ecosystem diversity and its resilience to changes in the environment.

Essential Knowledge

Natural and artificial ecosystems with fewer component parts and with little diversity among the parts are often less resilient to changes in the environment.
Keystone species, producers, and essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem.

Learning Objective

Explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long- term structure.

Essential Knowledge

The diversity of species within an ecosystem may influence the organization of the ecosystem.
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.

TOPIC 8.7: Disruptions to Ecosystems

Enduring Understanding
Competition and cooperation are important aspects of biological systems.

Learning Objective
Explain how invasive species affect ecosystem dynamics.

Essential Knowledge
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.
The availability of resources can result in uncontrolled population growth and ecological changes.

Learning Objective
Describe human activities that lead to changes in ecosystem structure and/ or dynamics.

Essential Knowledge
The distribution of local and global ecosystems changes over time.
Human impact accelerates change at local and global levels—

a. The introduction of new diseases can devastate native species.
b. Habitat change can occur because of human activity.

Learning Objective
Explain how geological and meteorological activity leads to changes in ecosystem structure and/or dynamics.

Essential Knowledge
Geological and meteorological events affect habitat change and ecosystem distribution. Biogeographical studies illustrate these changes.