Unit 1 Chemistry of Life: Properties of Water and Macromolecules

Essential Question: What are the essential molecules of life and how are they used?

Unit Overview: Macromolecules are necessary for life processes. Understanding the structure of these molecules leads to an understanding of how they function.

State Standards:
Prerequisite knowledge;
B.C.2: Cellular processes
Living cells interact with, and can have an impact on, their environment. Carbon is a necessary element that cells acquire from their environment. Cells use carbon, along with hydrogen, oxygen, nitrogen, phosphorous and sulfur, during essential processes like respiration, photosynthesis, chemosynthesis and biosynthesis of macromolecules (e.g., proteins, lipids, carbohydrates). Chemical reactions that occur within a cell can cause the storage or release of energy by forming or breaking chemical bonds. Specialized proteins called enzymes lower the activation energy required for chemical reactions, increasing the reaction rate. Positive and negative feedback mechanisms regulate internal cell functions as external conditions vary. Most cells function within a narrow range of temperature and pH. Variations in external conditions that exceed the optimal range for a cell can affect the rate at which essential chemical reactions occur in that cell. At very low temperatures, reaction rates are slow. High temperatures can irreversibly change the structure of most protein molecules. Changes in pH beyond the optimal range of the cell can alter the structure of most protein molecules and change how molecules within the cell interact. The sequence of DNA bases on a chromosome determines the sequence of amino acids in a protein. Enzymatic proteins catalyze most chemical reactions in cells. Protein molecules are long, folded chains made from combinations of 20 common amino-acids. The activity of each protein molecule results from its sequence of amino acids and the shape the chain takes as a result of that sequence.

Key Terms:
Acid
Activation energy
Active site
Adhesion
Amino acid
Base
Bond
Buffer
Capillary Action
Carbohydrate
Cohesion
Covalent bond
Disaccharide
Enzyme
Fatty acid
Glycerol
Hydrogen Bond
Hydrophobic
Hydrophilic
Indicator
Ionic Bond
Lipid
Macromolecule
Monomer
Monosaccharide
Nucleic Acid
Nucleotide
pH
Polarity
Polymer
Polymerization
Polypeptide
Polysaccharide
Product
Protein
Reactant
Solute
Solution
Solvent

	Substrate Surface Tension

Objectives:
-Describe the properties of water
-Differentiate between covalent, ionic and hydrogen bonding
-Identify the monomer and function of each macromolecule
-Provide examples of macromolecules
-Understand the role of an enzyme
-Determine factors that affect the function of enzymes
-Understand the importance of the relationship between shape and function in proteins
-Describe how environmental factors affect the rate of enzyme activity

*Instructional Resources can be found in Schoology department folder

Unit 2 Cells: Cell Structure and Function (Microscopes)

Essential Question: How does the cell work as a functional system? **Unit Overview:** The cell is the basic unit of life. It works as a system itself and as part of a larger system. There will be a focus on how parts of a cell work as a functioning system, allowing cells to be specialized for specific jobs. Students will use microscopes to view various types of cells. <u>State Standards:</u> **B.C.1: Cell structure and function** • Structure, function and interrelatedness of cell organelles • Eukaryotic cells and prokaryotic cells	<u>Key Terms:</u> Active Transport Cell Membrane Cell Theory Centriole Chloroplast Cilia Concentration Gradient Cytoplasm Cytoskeleton Diffusion DNA/Chromatin

Every cell produces a membrane through which substances pass differentially, maintaining homeostasis. Molecular properties and concentration of the substances determine which molecules pass freely and which molecules require the input of energy. In all but quite primitive cells, a complex network of proteins provides organization and shape. Within the cell are specialized parts that transport materials, transform energy, build proteins, dispose of waste and provide information feedback and movement. Many chemical reactions that occur in some cells of multicellular organisms do not occur in most of the other cells of the organism. Prokaryotes, simple single-celled organisms, are first found in the fossil record about 3.8 billion years ago. Cells with nuclei, eukaryotes, developed one billion years ago and from these increasingly complex multicellular organisms descended.	Endoplasmic Reticulum Equilibrium Eukaryotic Facilitated Diffusion Flagella Golgi Lysosome Mitochondria Multicellular Nucleolus Nucleus Organelle Osmosis Passive Transport Phospholipid Bilayer Pseudopod Prokaryotic Protein Ribosome Unicellular Vacuole Vesicle

Objectives:

-The students can explain that the cell is a functioning system and how the structure of the parts facilitate their function
-The students can explain how cell components work together to perform the functions of the cell.
-The students can identify and describe that the cell has specialized parts for the transport of materials, energy transformation, protein building, waste disposal, and movement
-The students can differentiate between a prokaryotic and eukaryotic cells and between plant and animal cells
-Differentiate between active and passive transport
-Interpret diagrams of cellular transport
-The students can demonstrate how cells maintain homeostasis
-Identify parts of a compound microscope
-Properly focus a microscope into view

*Instructional Resources can be found in Schoology department folder

Unit 3 Cellular Processes

Essential Questions: How do cells operate as the basic function of life?
How do individual cells maintain homeostasis?

Unit Overview: Cells maintain homeostasis through cellular processes. Cells create and breakdown molecules to produce and release energy and/or building blocks to maintain balance.

State Standards:

B.C.2: Cellular processes

Living cells interact with, and can have an impact on, their environment. Carbon is a necessary element that cells acquire from their environment. Cells use carbon, along with hydrogen, oxygen, nitrogen, phosphorus and sulfur, during essential processes like respiration, photosynthesis, chemosynthesis and biosynthesis of macromolecules (e.g., proteins, lipids, carbohydrates). Chemical reactions that occur within a cell can cause the storage or release of energy by forming or breaking chemical bonds. Specialized proteins called enzymes lower the activation energy required for chemical reactions, increasing the reaction rate. Positive and negative feedback mechanisms regulate internal cell functions as external conditions vary. Most cells function within a narrow range of temperature and pH. Variations in external conditions that exceed the optimal range for a cell can affect the rate at which essential chemical reactions occur in that cell. At very low temperatures, reaction rates are slow. High temperatures can irreversibly change the structure of most protein molecules. Changes in pH beyond the optimal range of the cell can alter the structure of most protein molecules and change how molecules within the cell interact. The sequence of DNA bases on a chromosome determines the sequence of amino acids in a protein. Enzymatic proteins catalyze most chemical reactions in cells. Protein molecules are long, folded chains made from combinations of 20 common amino-acids. The activity of each protein molecule results from its sequence of amino acids and the shape the chain takes as a result of that sequence.

Key Terms:
Photosynthesis
Chemosynthesis
light reactions (light dependent reactions)
dark reactions (Calvin Cycle)
light independent
chloroplast
stroma
thylakoid
ATP/ADP and Pi
NADH/FADH2
Endergonic vs. exergonic
Photosynthesis
Chlorophyll
Glucose
Thylakoid membrane
ATP Synthase
Cellular respiration
Mitochondria
Cristae
Glycolysis
Pyruvate
Aerobic vs. anaerobic respiration
Alcoholic fermentation
Lactic acid fermentation
Krebs Cycle (Citric Acid Cycle)
Electron transport chain

Objectives:
Objectives:
Students will be able to...
-Explain how cells maintain homeostasis
-identify the reactants and products of photosynthesis/chemosynthesis and cellular respiration
-Identify and explain where the various stages of photosynthesis occur within the chloroplast
-identify where the different stages of respiration occur in the mitochondria
-explain how energy is stored in and released from ATP
-students will be able to follow the capture and release of energy throughout biochemical pathways

Unit 4 Cell Growth and Division

Essential Questions:
How are new cells made to replace dead/diseased cells or to allow for growth and specialization?

Unit Overview: Cells have a life cycle which includes mitosis. This process is controlled by various molecules and when left unchecked, results in cancer.

Objectives:
Students will be able to…
-describe each phase of the cell cycle
-identify which stage of the cell cycle a cell is in
-differentiate between benign and malignant tumors
-identify potential causes of cancer
-describe how cancer results from uncontrolled cell growth due to breakdowns in cell cycle control

Key Terms:
Cell Cycle
Mitosis
Cancer
Cell differentiation
Sister chromatids
Centromeres
Interphase
Prophase
Metaphase
Anaphase
Telophase
Spindle fiber
G1, S, G2
Apoptosis
Cytokinesis
Telomere

Advanced/Honors Vocab:
Centrioles
Stem cell
Pluripotent
Multipotent
Totipotent
Cyclin
Undifferentiated
iPS cells

Unit 5 Genetics	
Essential Questions: How is genetic information passed from organism to offspring? **Unit Overview:**This topic focuses on the explanation of genetic patterns of inheritance. Students will learn how the process of meiosis relates to the genetic inheritance of traits. In addition, students will learn various patterns of inheritance. **State Standards:** B.H.1: Cellular genetics Life is specified by genomes. Each organism has a genome that contains all the biological information needed to develop and maintain that organism. The biological information contained in a genome is encoded in its deoxyribonucleic acid (DNA) and is divided into discrete units called genes. Genes code for proteins. Different parts of the genetic instructions are used in different types of cells, influenced by the cell's environment and history. The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. B.H.3: Genetic mechanisms and inheritance Genetic variation in traits among offspring is a result of the movement of chromosomes crossing over, independent assortment, and recombination during gamete formation. Gene interactions described in middle school were limited primarily to dominant and codominant traits. In high school, genetic mechanisms, both classical and modern, including incomplete dominance, sex-linked traits, and dihybrid crosses, are investigated through real-world examples. Statistics and probability allow us to compare observations made in the real world with predicted outcomes. Dihybrid crosses can be used to explore linkage groups, gene interactions and phenotypic variations. Chromosome maps reveal linkage groups.	**Key Terms:** Meiosis Chromosome Haploid Diploid Gametes Somatic cells Crossing over Homologous chromosomes Sister chromatids Monohybrid cross Dihybrid cross Genotype Phenotype Homozygous Heterozygous Genotypic ratio Phenotypic ratio Pedigree Recombination Epistasis Incomplete dominance Cominance Polygenic Sex-Linked Traits Cloning Altered Gene

	Point Mutation Chromosomal mutation

Objectives:
Students will be able to…
-Explain the purpose of meiosis and how it is different from mitosis.
-Differentiate between haploid and diploid cells
-Explain what crossing over is and identify the phase it takes place during
-Complete a monohybrid cross
-Complete a dihybrid cross
-Differentiate between genotype and phenotype
-Determine the probability of a specific genotype or phenotype using a punnett square
-Differentiate between homozygous and heterozygous
-Calculate phenotypic ratios and genotypic ratios
-Write the genotype when given the phenotype and vice versa
-Complete a punnett square for a sex-linked trait
-Analyze a pedigree
-Create a pedigree

Unit 6 DNA	
Essential Questions: What is the significance of genetic information in DNA? Unit Overview: Genes are segments of DNA molecules. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein. Inserting, deleting or substituting segments of DNA molecules can alter genes. State Standards B.H.2: Structure and function of DNA in cells Mendel's laws of inheritance (introduced in grade 8) are interwoven with current knowledge of DNA and chromosome structure and function to build toward basic knowledge of modern genetics. Genes are segments of DNA molecules. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein. Inserting, deleting or substituting segments of DNA molecules can alter genes. Sorting and recombination of genes in sexual reproduction and meiosis specifically result in a variance in traits of the offspring of any two parents. This content can be explicitly connected to evolution. B.C.2: Cellular processes The sequence of DNA bases on a chromosome determines the sequence of amino acids in a protein. Enzymatic proteins catalyze most chemical reactions in cells. Protein molecules are long, folded chains	Key Terms: Deoxyribonucleic acid Nucleotide Nitrogen bases Ribonucleic acid mRNA tRNA rRNA Amino Acid Polypeptide Protein codon Transcription Translation Mutation Gene mutation Point mutation Substitution Frameshift mutation

made from combinations of 20 common amino-acids. The activity of each protein molecule results from its sequence of amino acids and the shape the chain takes as a result of that sequence. B.H.4: Mutations Genes can be altered by insertion, deletion, or substitution of a segment of DNA molecules. An altered gene is a mutation and will be passed on to every cell that develops from it. The resulting features may help, harm or have little or no effect on the offspring's success in its environments. Gene mutations in gametes are passed onto offspring.	Insertion Deletion Chromosomal mutation Duplication Translocation Nondisjunction

Objectives:
Students will be able to…
-describe the location, structure and function of DNA
-match complementary base pairs in a DNA sequence
-differentiate between DNA and RNA
-describe the molecules and organelles involved in the process of synthesising proteins
-transcribe and translate a gene sequence
-differentiate between different types of mutations

Unit 7 Evolution	
Essential Questions: What causes populations to change over generations? Unit Goal: The basic concept of biological evolution is that Earth's present-day species descended from earlier, common ancestral species. The study of evolution includes the unification of genetics and evolution, historical perspectives of evolutionary theory, gene flow, mutation, speciation, natural selection, genetic drift and sexual selection. State Standards B.E.1: Mechanisms: Natural selection is used to describe the process by which traits become more or less common in a population due to consistent environmental pressures upon the survival and reproduction of individuals with the trait. Mathematical reasoning is applied to solve problems (e.g., use Hardy-Weinberg principle to explain deviations in observed gene frequency patterns in a population compared to expected patterns based on the assumptions of the principle). Populations evolve over time. Evolution through natural selection is the consequence of the interactions of: 1. The potential for a population to increase its numbers; 2. The genetic variability of offspring due to mutation and recombination of genes; 3. A finite supply of the resources required for life; and 4. The differential survival and reproduction of individuals based on phenotype(s). B.E.2:Speciation:	Key Terms: Evolution Microevolution Macroevolution Population Species Gene Pool Genetic Equilibrium Allele frequency Variation Adaptation Descent with Mod. Mechanisms Natural selection Sexual selection Mutation Gene flow Genetic Drift Bottleneck effect Founders effect

Biological classification expanded to molecular evidence Classification systems are frameworks, developed by scientists, for describing the diversity of organisms; indicating the degree of relatedness among organisms. Recent molecular sequence data generally support earlier hypotheses regarding lineages of organisms based upon morphological comparisons. Both morphological and molecular comparisons can be used to describe patterns of biodiversity (cladograms present hypotheses to explain descent from a common ancestor with modification). The concept of descent from a common ancestor with modification provides a natural explanation for the diversity of life on Earth as partially represented in the fossil record and in the similarities of existing species.	Immigration Emigration Speciation Convergent evolution Divergent evolution Gradualism Punctuated equilibrium Coevolution Extinction (mass and gradual) transitional fossils vestigial structures homologous structures analogous structures Embryology

Objectives:
Students will be able to…
-explain that the evolution of a species is a change in gene frequency
- differentiate between mechanisms of speciation (gene flow, mutation, speciation, natural selection, genetic drift, sexual selection)
- describe evidence for evolution (e.g., fossil record, molecular and structural homology, biogeography)
-state evidence of evolutionary theory from real-world examples (e.g., antibiotic resistant bacteria)
-explain different scenarios in which environmental changes influence selective pressure on a population
- interpret tables or data showing gene frequency changes over time
-interpret cladograms showing relationships between species
-explain how variations within populations in a changing environment can lead to evolution
-describe how speciation occurred in two related populations

Unit 8 Ecology

Essential Questions: How do organisms interact with each other in order to allow energy and matter to flow through an ecosystem, and what is the human impact on this flow?

Unit Goal: This unit focuses on the flow of energy and the cycling of matter as organisms grow, reproduce and die. At the high school level, diagrams and models are used to explain the effects of real-world interactions and events within an ecosystem.

State Standards

B.DI.1: Biodiversity

The great diversity of organisms and ecological niches they occupy result from more than 3.8 billion years of evolution. Populations of individual species and groups of species comprise a vast reserve of genetic diversity. Loss of diversity alters energy flow, cycles of matter and persistence within biological communities. Loss of genetic diversity in a population increases its probability of extinction.

B.DI.2: Ecosystems

Ecosystems change as geological and biological conditions vary due to natural and anthropogenic factors. Like many complex systems, ecosystems have cyclical fluctuations around a state of equilibrium. The rate of these fluctuations in ecosystems can increase due to anthropogenic factors. Changes in ecosystems may lead to disequilibrium, which can be seen in variations in carrying capacities for many species. Authentic data are used to study the rate of change in matter and energy relationships, population dynamics, carbon and nitrogen cycling, population changes and growth within an ecosystem. Graphs, charts, histograms and algebraic thinking are used to explain concepts of carrying capacity of populations and homeostasis within ecosystems by investigating changes in populations that occur locally or regionally. Mathematical models can include the exponential growth model and the logistic growth model. The simplest version of the logistic growth model is Population Growth Rate = rN(K-N)/K, which incorporates the biological concept of limited (non-infinite) carrying capacity, based upon intra- and interspecies competition for resources such as food, as represented by the variable K. Carrying capacity is defined as the population equilibrium size when births and deaths are equal; hence Population Growth Rate = zero.

B.DI.3: Loss of diversity

An ecosystem will maintain equilibrium with small fluctuations in its abiotic and biotic components, but significant fluctuations can result in long-term alterations of the ecosystem and ultimately a loss of biodiversity. This can be caused by natural and anthropogenic events. Humans are a biotic factor in ecosystems and can impact critical variables within these systems. Climate is dependent on a number of feedback loops between sunlight, the ocean, the atmosphere and the biosphere. Increasing mean global temperatures cause increased variance in weather that impacts both biotic and abiotic factors. Multiple changes happening simultaneously can stress ecosystems. Extreme events such as prolonged drought, floods, or the introduction or removal of species can result in long-term alterations to ecosystems and their functions. The current rate of extinction is at least 100-1000 times the average background rate observed in the fossil record. The observed rates of biodiversity loss are indicative of a severe and pervasive disequilibrium in ecosystems. At the high school level, students should examine the factors that contribute to the accelerated extinction rates observed today and the implications of declining biodiversity carrying capacity. Misconceptions about population growth capacity, interspecies

Key Terms:

Niche
habitat
Ecosystem
Homeostasis
Immigration
Emigration
Competition
Biodiversity
Carrying capacity
Population
abiotic/biotic factors
Nutrient cycles
Population density
Logistic/exponential growth
Limiting factors
Distribution
Succession
Symbiosis
Inter/Intra species interactions
Community
Biome
Biosphere
Species

and intraspecies competition for resources, and what occurs when members of a species immigrate to or emigrate from ecosystems are included in this topic. Technology can be used to access real-time/authentic data to study population changes and growth in specific locations.	

Objectives:
Students will be able to…
-differentiate between the levels of ecology
-identify an organism's habitat and niche in an ecosystem and explain how changing them affects organisms
-differentiate between abiotic and biotic factors in an ecosystem
-explain how limiting factors affect population growth
-explain how population demographics (birth rate, death rate, immigration, emmigration) affect population growth
-recognize and differentiate between primary and secondary succession
-trace the movement of carbon and nitrogen through nutrient cycles
-explain how organisms benefit or are harmed within their various ecological relationships

Unit 9 Genetic Engineering

Essential Questions: How and why do scientists manipulate DNA in living cells?

Unit Goal: In this unit the concept of manipulating the genetic code of living things is explored. Scientists increase genetic variation by inserting genes from one organism into another, or by causing mutations. Scientists can copy the DNA of living organisms or even produce copies of living organisms. Scientists can modify the DNA of plants, animals, and bacteria to produce products that can be used as medicine, to solve world problems such as hunger and pollution, and create new varieties of food. DNA fingerprinting is an old technology used to identify individuals from one another. Today, DNA profiling uses STR analysis. CRISPR has made genetic engineering much easier in humans and has shown incredible promise in recent years/months.

State Standards
B.H.5: Modern genetics
Technological developments that lead to the current knowledge of heredity are introduced for study. The development of the model for DNA structure was the result of experimentation, hypothesis, testing, statistical analysis and technology as well as the studies and ideas of many scientists. James Watson and Francis Crick developed the current model based on the work of Rosalind Franklin and others. Scientists continue to extend the model and use it to devise technologies to further our understanding and application of genetics. The emphasis is not on the memorization of specific steps of gene technologies, but rather on the interpretation and application of the results

Key Terms:

CRISPR
Guide RNA
Gene drive
Restriction enzymes
Gel electrophoresis
DNA fingerprinting
STR profile
Forensics
Polymerase Chain Reaction
Biotechnology
Recombinant DNA
Transformation
Transgenic Organism
Plasmid
Genetic marker
Cloning
Genetically Modified Organism
Gene Therapy
Human Genome Project
Humulin
Golden Rice

Objectives:
Students will be able to explain how scientists manipulate DNA.
Describe the importance and process of forming recombinant DNA.
Define transgenic and describe the usefulness of some transgenic organisms to humans.
Describe the benefits of genetic engineering as they relate to agriculture and industry.
Explain how recombinant DNA technology can improve human health.
Summarize the process of DNA fingerprinting, explain its uses, and know how it has advanced to the newer technology of STR analysis.
Students will recognize the significant difference between somatic cell vs. germ line gene editing and the ethical implications of such modifications.
Students will investigate the most recent discoveries and advances in gene therapy and CRISPR technology.