

## 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.

State Standards:

**B.C.1: Cell structure and function**

- Structure, function and interrelatedness of cell organelles
- Eukaryotic cells and prokaryotic cells

Key Terms:

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

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### 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

**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, emigration) 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.

