Havre Public Schools Advanced Biology High School

Course Information
Course Title: Principles of Living Systems with Lab (dual credit with Great Falls College-MSU)
Course Number: BIOB 160
Number of Dual Enrollment Credits: 1 (High School) 4 - 3 Lecture + 1 Lab (College)
Grade Level: 11 and 12
Length: 1 Year
Period(s) Per Day: 1

Course Description: This course is designed to help students understand and apply major concepts in molecular and cellular biology including biological macromolecules, cell structure and function, major biological pathways (cellular respiration and photosynthesis), cell division, Mendelian genetics, modern biotechnology, early development, and major control mechanisms within the body.

Essential Understandings:

Essential Understanding *BIG IDEA 1: THE PROCESS OF ORGANISMS CHANGING THROUGH TIME DRIVES DIVERSITY AND UNITY OF LIFE.*	Examples Covered
Natural Selection is a major mechanism of diversity of life.	• Graphical analysis of allele frequencies in a population • Application of Hardy-Weinberg Equation
Natural Selection acts on phenotypic variations in populations.	• Peppered moth • Sickle cell anemia • Artificial selections • Overuse of antibiotics • Loss of genetic diversity within crop species
Biological diversity between species is supported by scientific evidence from many disciplines, including mathematics.	• Graphical analysis of allele frequencies in a population • Analysis of sequence data sets
Speciation and extinction have occurred throughout the Earth's history.	• Five major extinctions • Human impact on ecosystems and species extinction rates
Speciation may occur when two population become reproductively isolated from each other.	• Island biogeography
Populations of organisms continually adapt to their environments.	• Chemical resistance • Emergent diseases • Observed directional phenotypic change in a population

Essential Understanding *BIG IDEA 2: BIOLOGICAL SYSTEMS UTILIZE FREE ENERGY AND MOLECULAR BUILDING BLOCKS TO GROW, TO REPRODUCE AND TO MAINTAIN DYNAMIC HOMEOSTASIS.*	Examples Covered
All living systems require constant input of free energy.	• Krebs Cycle • Glycolysis • Calvin Cycle • Fermentation • Endothermy is the use of thermal energy generated by metabolism to maintain homeostatic body temperatures. • Ectothermy is the use of external thermal energy to help regulate and maintain body temperature.
Organisms capture and store free energy for use in biological processes.	• NADP+ in photosynthesis • Oxygen in cellular respiration
Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.	• Cohesion • Adhesion • High specific heat capacity • Universal solvent supports reactions. • Heat of vaporization
Cell membranes are selectively permeable due to their structure.	• Phospholipid bilayer • Aquaporins • Protein membranes
Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.	• Glucose transport • Na+/K+ transport
Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.	• Endoplasmic Reticulum • Mitochondria • Chloroplasts • Golgi Apparatus • Nuclear Envelope
Organisms use negative feedback mechanisms to maintain their internal environments and respond to external environmental changes.	• Operons in gene regulation

Essential Understanding *BIG IDEA 3: LIVING SYSTEMS STORE, RETRIEVE, TRANSMIT, AND RESPOND TO INFORMATION ESSENTIAL TO LIFE PROCESSES.*	Examples Covered

DNA, and in some cases RNA, is the primary sources of heritable information.	● Addition of a poly-A tail ● Addition of a GTP cap ● Excision of introns ● Enzymatic reactions ● Transport by proteins ● Synthesis ● Electrophoresis ● Plasmid-based transformation ● Restriction enzyme analysis of DNA ● Polymerase Chain Reaction (PCR) ● Genetically modified foods ● Transgenic animals
In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis, or meiosis plus fertilization.	● Cancer results from disruptions in cell cycle control
The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.	● Sickle cell anemia ● Cystic fibrosis ● Tay-Sachs ● Huntington's Disease ● X-linked Color Blindness ● Trisomy 21/Down's Syndrome ● Klinefelter Syndrome ● Civic issues such as ownership of genetic information.
The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.	● Sex-linked genes reside on sex chromosomes (X in humans). ● In mammals and flies, the Y chromosome is very small and carries very few genes. ● In mammals and flies, X-linked recessive traits are always expressed in males. ● Some traits are sex limited, and expression depends on the sex of the individual, such as pattern baldness in males.
Gene regulation results in differential gene expression, leading to cell specialization.	● Promoters ● Terminators ● Enhancers
A variety of intercellular and intracellular signal transmissions mediate gene expression.	● Cytokines regulate gene expression to allow for cell replication and division. ● Levels of cAMP regulate metabolic gene expression in bacteria.

	• Expression of the SRY gene triggers the male sexual development in animals.
Changes in genotype can result in changes in phenotype.	• Antibiotic resistance mutations • Pesticide resistance mutations • Sickle cell disorder and heterozygote advantage
Biological systems have multiple processes that increase genetic variation.	• Genetic recombination during the process of crossing-over of bivalent forms exchange genetic material. • Independent assortments of homologous chromosomes
Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.	• Transduction in bacteria • Transposon present in incoming DNA
Cell communication processes chare common features.	• DNA repair mechanisms

Essential Understanding *BIG IDEA 4: BIOLOGICAL SYSTEMS INTERACT, AND THESE SYSTEMS AND THEIR INTERACTIONS POSSESS COMPLEX PROPERTIES.*	Examples Covered
The subcomponents of biological molecules and their sequence determine the properties of that molecule.	• Water has a high heat of evaporation. • Hydrogen bonding • Water molecules are cohesive and adhesive
The structure and function of subcellular components, and their interactions, provide essential cellular processes.	• All cells are produced from existing cells. • Eukaryotic cells contain multiple cooperating and specialized organelles which produce the structure and accomplish the functions necessary for life.
Interactions between external stimuli and regulated gene expression result in specialization of cells.	• Every cell contains DNA with encrypts the information for all its structures and functional molecules.
Cooperative interactions within organisms promote efficiency in the use of energy and matter.	• Exchange of gasses • Photosynthesis • Cellular respiration
Variation in molecular units provides cells with a wider range of functions.	• Different types of hemoglobin • Chlorophylls

Environmental factors influence the expression of genotype in an organism.	• Effect of adding lactose to a Lac + bacterial culture

Themes:

Big Idea 1: The process of organisms changing through time drives diversity and unity of life.

Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes.

Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

Course objectives/expectations:

- Use quantitative information and/or mathematical analysis to obtain sound results and recognize questionable assumptions.
- Demonstrate understanding of the broad principles of science and ways scientists in a particular discipline conduct research.
- Make observations, understand the fundamental elements of experimental design, generate, and analyze data using appropriate quantitative tools, use abstract reasoning to interpret the data and formulae, and test hypothesis with scientific rigor.
- Understand the role of diversity of living things.
- Demonstrate proficiency in collection, interpretation, and presentation of scientific data.

Student Objectives:

Students will:

- Develop skills handling laboratory equipment.
- Understanding of scientific methodology.
- List the four major macromolecules found in cells.
- Explain the four major macromolecules' composition and function in cells.
- List, describe, and identify the parts of a eukaryotic cell.
- Describe the process of cellular respiration (Glycolysis, Krebs Cycle, and Electron Transport Chain).
- Describe anaerobic respiration (two types of fermentation).
- Describe the steps of photosynthesis (light reactions and the Calvin Cycle).
- Describe DNA replication, Mitosis, Meiosis, and the cell cycle.
- Explain Mendelian genetics.
- Solve genetics problems using Punnett squares and rules of probability.
- Explain the chromosomal and molecular basis of inheritance.
- Explain the process of protein synthesis.
- Explain the principles of gene regulation.

Pacing/timeline/NGSS content standard:

Pacing	Content	NGSS Content Standard
Quarter 1		
Week 1	Defining Life/Unifying Concepts of Biology	HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
Week 2	The Process of Science	Constructing Explanations and Designing Solutions: Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-1)
Week 3	Chemical Elements, Molecules, and Compounds	Structure and Function Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-LS1-1)
Week 4	Chemistry of Water, Acids and Bases	Structure and Function Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-LS1-1)
Week 5	Organic Molecules-Carbohydrates, Lipids, Proteins, Nucleic Acids	HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.
Week 6	Prokaryotic and Eukaryotic Cells	LS1.A: Structure and Function Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
Week 7	Nucleus, Ribosomes/Endomembrane Systems	LS1.A: Structure and Function Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
Week 8	Vesicles, Vacuoles, Energy-Related Organelles	LS1.A: Structure and Function Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
Week 9	Plasma Membrane Structure and Function	LS1.A: Structure and Function Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)

Quarter 2		
Week 10	Passive and Active Transport Across a Membrane	HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
Week 11	Modification of Cell Surfaces/Flow of Energy	HS-LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy.
Week 12	Metabolic Reactions and Energy Transformations	HS-LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy.
Week 13	Metabolic Pathways and Enzymes	HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
Week 14	Organelles and the Flow of Energy	HS-LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy.
Week 15	Photosynthetic Organisms	HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
Week 16	Process of Photosynthesis-Light Dependent/Calvin Cycle	HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
Week 17	Plants as Solar Energy Converters	HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
Week 18	Plants as Carbon Dioxide Fixers	HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
Quarter 3		
Week 19	Cellular Respiration	LS1.C: Organization for Matter and Energy Flow in Organisms As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken, and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7)
Week 20	Outside the Mitochondria – Glycolysis and Fermentation	LS1.C: Organization for Matter and Energy Flow in Organisms

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Week 21	Inside the Mitochondria – Krebs Cycle and ETC	LS1.C: Organization for Matter and Energy Flow in Organisms As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken, and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7)
Week 22	The Cell Cycle- Mitosis and Cytokinesis	HS-LS1-4: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
Week 23	The Cell cycle and Cancer	HS-LS1-4: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
Week 24	Prokaryotic Cell Division	HS-LS1-4: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
Week 25	Halving Chromosome Number/Genetic Variation	HS-LS3-2: Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
Week 26	Phases of Meiosis	LS3.B: Variation of Traits In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)
Week 27	Meiosis Compared to Mitosis	HS-LS3-2: Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis.

Quarter 4		
Week 28	Gregor Mendel/Mendel's Laws	HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
Week 29	Extending Range of Mendelian Genetics	HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
Week 30	Genetic Material (DNA)/Replication of DNA	LS1.A: Structure and Function All cells contain genetic information in the form of DNA molecules. Genes are regions in DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1)
Week 31	Replication of DNA	LS3.B: Variation of Traits In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)
Week 32	Genetic Code of Life	LS3.A: Inheritance of Traits Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)
Week 33	Protein Synthesis – Transcription/Translation	HS-LS1-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.
Week 34	Structure of Eukaryotic Chromosome	LS3.A: Inheritance of Traits Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated

		in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)
Week 35	Prokaryotic and Eukaryotic Regulation	Structure and Function: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-LS1-1)
Week 36	Gene Mutations/DNA Cloning/Biotechnology Products	HS-LS4-2: Construct an explanation based on evidence that the process of changes in organisms results from: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
Week 37	Gene Therapy/Genomics	Science is a Human Endeavor: Technological advances have influenced the progress of science and science has influenced advances in technology. (HS-LS3-3) Science and engineering are influenced by society and society is influenced by science and engineering. (HS-LS3-3)

Course Outline:

A. A View of Life
  a. How to Define Life
  b. Unifying Concepts of Biology
  c. How the Biosphere is Organized
  d. The Process of Science
B. Basic chemistry
  a. Chemical Elements
  b. Molecules and Compounds
  c. Chemistry of Water
  d. Acids and Bases
C. The Chemistry of Organic Molecules
  a. Organic Molecules
  b. Carbohydrates
  c. Lipids
  d. Proteins
  e. Nucleic Acids
D. Cell Structure and Function
  a. Cellular Level of Organization
  b. Prokaryotic Cells
  c. Eukaryotic Cells
  d. The Nucleus and Ribosomes

    e. The Endomembrane System
    f. Other Vesicles and Vacuoles
    g. The Energy-Related Organelles
    h. The Cytoskeleton
E. Membrane Structure and Function
    a. Plasma Membrane Structure and Function
    b. Passive Transport Across a Membrane
    c. Active Transport Across a Membrane
    d. Modification of Cell Surfaces
F. Metabolism: Energy and Enzymes
    a. Cells and the Flow of Energy
    b. Metabolic Reactions and Energy Transformations
    c. Metabolic Pathways and Enzymes
    d. Organelles and the Flow of Energy
G. Photosynthesis
    a. Photosynthetic Organisms
    b. The Process of Photosynthesis
    c. Plants as Solar Energy Converters
    d. Plants as Carbon Dioxide Fixers
    e. Other Types of Photosynthesis
H. Cellular Respiration
    a. Cellular Respiration
    b. Outside the Mitochondria: Glycolysis
    c. Outside the Mitochondria: Fermentation
    d. Inside the Mitochondria
    e. Metabolic Pool
I. The Cell Cycle and Cellular Reproduction
    a. The Cell Cycle
    b. Mitosis and Cytokinesis
    c. The Cell Cycle and Cancer
    d. Prokaryotic Cell Division
J. Meiosis and Sexual Reproduction
    a. Halving the Chromosome Number
    b. Genetic Variation
    c. The Phases of Meiosis
    d. Meiosis Compared to Mitosis
    e. The Cycle of Life
    f. Changes in the Chromosome Number and Structure
K. Mendelian Patterns of Inheritance
    a. Gregor Mendel
    b. Mendel's Laws
    c. Extending the Range of Mendelian Genetics
L. Molecular Biology of the Gene
    a. The Genetic Material
    b. Replication of DNA
    c. The Genetic Code of Life
    d. First Step: Transcription

    e. Second Step: Translation
    f. Structure of the Eukaryotic Chromosome
M. Regulation of Gene Expression
    a. Prokaryotic Regulation
    b. Eukaryotic Regulation
    c. Gene Mutations
N. Biotechnology and Genomics
    a. DNA Cloning
    b. Biotechnology Products
    c. Gene Therapy
    d. Genomics

Resources

Next Generation Science Standards, Disciplinary Core Ideas, and Crosscutting Concept.

Mader, Biology, AP Edition, 2022 14e Student Edition

Skloot, Immortal Life of Henrietta Lacks

Science Standards- https://opi.mt.gov/LinkClick.aspx?fileticket=qHA5q8j-oGw%3d&portalid=182 Comparison MT Sci Content Standards and NGSS.pdf

Model Curriculum Guide https://opi.mt.gov/Educators/Teaching-Learning/K-12-Content-Standards/Science-Standards#88989482-resources

Approved: 03/11/2025