COURSE INFORMATION

Biology

Grade Level: 9 (completion of Algebra 1), 10
Length: 1 Year
Period(s) per Day 1

ESSENTIAL UNDERSTANDING

Biology utilizes a standard's aligned curriculum framework to encompass the essential concepts of biological science. The study of biology will revolve around analyzing and explaining the nature of science in the search for understanding the natural world, as well as practice the application of technology, scientific tools and critical thought in solving problems. The focus will be on the biological structures and their functions at multiple levels of organization in living things, as well as explore the patterns, processes and systems within biology. As scientific learners, Students will collect and analyze data, interpret results, draw conclusions and communicate their findings. Throughout the course, students will work both independently and collaboratively, in a laboratory-based classroom with an active learner approach. The goal for the course is for students to gain a more meaningful understanding of the living world around them as well as having a deeper appreciation of their place in it.

THEME SAMPLES

Upon completion of Biology, the following underlying themes will be discussed and integrated in the units covered throughout the year:

Scientific Inquiry – Scientists us methods of inquiry to understand the natural world.

Homeostasis - Organisms use the resources in their environment to maintain homeostasis.

Change – To maintain homeostasis, organisms continually adapt to their environment.

Energy – All living organisms use energy to carry out all biological processes.

Diversity – Maintaining balance between organisms depends on biological diversity.

Course Structure

Each unit in Biology will be designed using the following format:

Engage	Students create a unit title page in their interactive notebooks, discussing and illustrating the "big picture" of content that they will learn in the unit.
Explore	Students actively explore concepts independently and collaboratively in a biology lab setting. Students also use manipulatives to simulate real-world biology concepts.
Explain	Students develop vocabulary, label diagrams, and define major concepts and processes through class and group discussion. Students create written explanation of the concepts learned as well.
Elaborate	Students develop a deeper and broader understanding of concepts in lab and in a variety of independent and group activities.
Evaluate	Students assess their understanding of the concepts learned during the unit

COURSE OBJECTIVES AND EXPECTATIONS

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS1-2),(HS-LS1-4)

Energy and Matter

- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6)
- Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS1-7)

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)

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1),(HS-LS3-2)

Scale, Proportion, and Quantity

- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-LS3-3)

Connections to Nature of Science

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)

STUDENT OBJECTIVES

Students mastering the material of this class will understand the following concepts:

1. All living things share the characteristics of life;
2. Cells are the structural and functional units of all living organisms;
3. Eukaryotic cells contain organelles that allow the specialization and the separation of functions within cells;
4. Cellular transport moves substances within the cell and moves substances into and out of the cell;
5. Organisms are made up of carbon-based molecules;
6. Light energy is trapped and converted into chemical energy during photosynthesis;
7. Living organisms obtain energy by breaking down organic molecules during cellular respiration;
8. Cells go through a life cycle that includes interphase, mitosis, and cytokinesis;
9. The process of meiosis leads to genetic diversity;
10. Genetic recombination leads to genetic diversity possibilities;
11. Mendel explained how a dominant allele can mask the presence of a recessive allele;
12. Complex forms of inheritance result in a wide diversity of characteristics;
13. Complex inheritance of traits does not follow inheritance patterns described by Mendel;
14. Inheritance of genes from generation to generation helps maintain homeostasis among species
15. Mutations in genes allow possible changes in inheritance to occur;

16. The discovery of the structure of DNA dramatically changed the field of biology;
17. The discovery of DNA led to an understanding of the inheritance of traits from one generation to the next;
18. DNA replicate by making a stand that is complementary to each original strand;
19. Mutations in DNA provide the possibility of extensive variation;
20. Mistakes within DNA are usually fixed before replication occurs;
21. DNA codes for RNA, which guides protein synthesis;
22. Biotic and abiotic factors interact in complex ways in communities and ecosystems;
23. Energy is required to cycle materials through living and nonliving systems;
24. Organisms in a population compete for energy sources, such as food and sunlight;
25. Limiting factors and ranges of tolerance are factors that determine where terrestrial biomes and aquatic ecosystems exist;
26. Population growth is a critical factor in a species' ability to maintain homoeostasis within its environment;
27. Community and ecosystem homeostasis depend on a complex set of interaction among biological diverse individuals;
28. Populations of species are described by density, spatial distribution, and growth rate;
29. Homeostasis within a population is controlled by density-dependent and density-independent limiting factors;
30. Constantly changing communities of plants and animals drive succession

PACING/TIMELINE AND STANDARDS

Course Outline

Unit Topic	Standards
Unit 1: Cell Discovery and Theory; Cell Structure and Function	LS1.A, HS-LS1-2
Unit 2: Plasma Membrane and Cellular Transport	LS1.A, HS-LS1-3
Unit 3: Biochemistry (Macromolecules)	HS-LS1-6
Unit 4: Photosynthesis	HS-LS1-5
Unit 5: Cellular Respiration	HS-LS1-7, HS-LS2-3
Unit 6: Cell Cycle and Cell Differentiation	HS-LS1-4
Unit 7: Meiosis	HS-LS3-2
Unit 8: Mendelian Genetics	HS-LS3-1
Unit 9: Non-Mendelian Inheritance Patterns	HS-LS3-1
Unit 10: Patterns of Human Inheritance	HS-LS3-2, HS-LS3-3
Unit 11: Molecular Genetics	LS3.A, HS-LS3-2, HS-LS3-3
Unit 12: RNA and Protein Synthesis	HS-LS1-1
Unit 13: Principles of Ecology	HS-LS2-6
Unit 14: Energy Flow in Ecosystems	HS-LS2-4
Unit 15: Ecological Succession	HS-LS2-2, HS-LS2-6

TIMELINE

Unit 1:	Cell Discovery & Theory: Cell Structure & Function	3 weeks
Unit 2:	Plasma Membrane & Cellular Transport	3 weeks
Unit 3:	Biochemistry (Macromolecules)	3 weeks
Unit 4:	Photosynthesis	3 weeks
Unit 5:	Cellular Respiration	3 weeks
Unit 6:	Cell Cycle & Cell Differentiation	3 weeks
Unit 7:	Meiosis	2 weeks
Unit 8:	Mendelian Genetics	2 weeks
Unit 9:	Non-Mendelian Inheritance Patterns	2 weeks
Unit 10:	Patterns of Human Inheritance	2 weeks
Unit 11:	Molecular Genetics (DNA)	2 weeks
Unit 12:	Transcription & Translation (Protein Synthesis)	2 weeks
Unit 13:	Principles of Ecology	2 weeks
Unit 14:	Energy Flow in an Ecosystems	2 weeks
Unit 15:	Ecological Succession	2 weeks

CONTENT STANDARDS

Students who demonstrate understanding can:

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.

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

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.

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.

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.

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.

HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

HS-LS2-8. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.

DISCIPLINARY CORE IDEAS

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1) (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)

LS1.B: Growth and Development of Organisms

- In multicellular organisms' individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4)

LS1.C: Organization for Matter and Energy Flow in Organisms

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5)
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HS-LS1-6)
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7)
- 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)

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)

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)
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS3-2),(HS-LS3-3)

LS2.A: Interdependent Relationships in Ecosystems

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental

tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1),(HS-LS2-2)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6)
- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

LS2.D: Social Interactions and Group Behavior

- Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (HS-LS2-8)

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HS-LS2-7)
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive

species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary to HS-LS2-7) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)

PS3.D: Energy in Chemical Processes

- The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary to HS-LS2-5)

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (secondary to HS-LS2-7)

RESOURCES

Next Generation Science Standards, Disciplinary Core Ideas, and Crosscutting Concepts: http://www.nextgenscience.org/overview-dci

Montana Office of Public Instruction Montana Science Model Curriculum Guide: 9-12 Earth and Space Science: http://montanateach.org/resources/montana-science-model-curriculum-guide-by-grade-level-grade-9-12-earth-and-space-science/