West Windsor-Plainsboro Regional School District
Course Title: Science ESL II (Biology)

The Mission of the West Windsor-Plainsboro Science Department

Our mission is to cultivate science learners who have the foundational knowledge to make ethical, scientifically literate decisions and the ability to apply scientific practices in order to contribute to the needs of society and a changing world.

- **Vision**

  We envision a K-12 science experience that supports and challenges every student in their science learning journey. We will:
  - *Capitalize on diversity by reaching and exciting students at all levels and interests by differentiating learning within classrooms and by offering a robust program of studies.*
  - *Emphasize authentic science and engineering practices and leverage the interdisciplinary nature of science with arts, technology, math, reading, and writing.*
  - *Integrate scientific knowledge and 21st century competencies to prepare students to make informed decisions and take action to address real world problems.*

Unit Title: Structure and Function	
Content Area: Science	
Course & Grade Level: ESL II Biology 9-12	
Summary and Rationale	
Students formulate an answer to the question: "How do the structures of organisms enable life's functions?" Students are able to investigate explanations for the structure and function of inorganic and organic compounds, cells as the basic units of life, the hierarchical systems of organisms, and the role of specialized cells for maintenance and growth. Students demonstrate understanding of how systems of cells function together to support the life processes. Students demonstrate their understanding through using models, designing and conducting investigations.	
Recommended Pacing	
25-30 weeks depending upon student level	
NGSS Standards/Performance Expectations	
Standard	
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. [Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.]
HS-LS1-2	Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [*Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.*]
HS-LS1-3	Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [*Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.*]
HS-LS1-4	Use a model to illustrate the role of cellular division [mitosis] and differentiation in producing and maintaining complex organisms. [*Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.*]
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 for form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [*Assessment Boundary: Assessment does not include complex chemical reactions.*]

Instructional Focus

Unit Enduring Understandings

- Structure and function: an atom, a molecule, or a cell's configuration determines its chemical and physical properties and hence its function.
- Patterns: the building blocks of life form more complex structures in recognizable patterns.
- Cellular function is maintained through the regulation of cellular processes in response to internal and external environmental conditions.
- Cell differentiation is regulated through the expression of different genes during the development of complex multicellular organisms.
- The instructions for forming species characteristics are carried in DNA which are determined by a sequence of amino acids, which results in specific proteins.

Unit Essential Questions

- If all atoms are composed of the same fundamental building blocks, how is it that different atoms can behave chemically in vastly different ways?
- What is the importance of carbon in living things?
- If all organisms are composed of the same building blocks, how can there be such great diversity among living things?
- How do prokaryotic and eukaryotic cells differ in structure and function?
- Can life on Earth exist without water? Why or why not?
- To get the building blocks (monomers) needed for making macromolecules (polymers), we must eat other organisms. To get these building blocks, does it matter if we eat just other animals, just plants or both animals and plants?
- Among the macromolecules (carbohydrates, lipids and proteins), how are proteins made, why is it that proteins can exhibit the greatest structural diversity? What is the purpose of this diversity?
- How do the different macromolecules affect our bodies and what are they used for in our bodies?
- Can we live by eating only DNA?
- Why are large organisms made of many cells and not just one cell?
- How are different molecules transported in and out of cells? What accounts for the different modes of cellular transport?

Content Statements

Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.

- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life.
- 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.
- 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.
- 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.

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.

Ability Objectives

General for all Units:

- Develop, design, model and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop technological literacy and an understanding of the role of information technologies in modern scientific endeavors.
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematics and computational thinking to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomena.
- Construct explanations and design solutions for complex real world environmental problems.

Learning Objectives Specific for Unit 1:

SWBAT:

- Differentiate between an atom, molecule, element and compound.
- Determine the structure and properties of atoms and molecules.
- Investigate and demonstrate properties of water and how they pertain to life on earth.
- Describe the patterns of bonding between atoms and molecules.
- Identify the properties of the four major organic compounds: proteins (with emphasis on enzymes), lipids, carbohydrates and nucleic acids.
- Explain how the four major organic compounds are essential components to the composition of our bodies.
- Explain the origins of life from inorganic compounds.

- Use a compound microscope to observe/study cells.
- Prepare and selectively stain cells on a slide to identify the basic structure of cells.
- Follow various biomolecules from its synthesis through to its final destination.
- Compare and contrast the structure and functions of different types of cells.
- Explain how the structure relates to the function of cellular organelles.
- Model the structure of the cell membrane and the mechanisms whereby substances enter and leave cells.
- Illustrate and model the process by which cells grow and reproduce and how the cell cycle is controlled.
- Model how the structure of DNA determines its function in DNA replication and protein synthesis.
- Explain how changes in certain environmental factors affect the structure/function of selected organic compounds. Explain how changes in pH, salinity/ion solute concentration and temperature extremes can affect the structure of a protein.
- Design and carry out a scientific investigation on how environmental factors affect the structure therein the function of enzymes.
- Predict a possible effect of a malfunctioning enzyme on an organism.
- Describe the effect of temperature on various modes of cell transport.
- Cite evidence that cells exist within a narrow range of environmental conditions and disturbance of the homeostasis of the cell can result in the death of a cell or organism.

<u>Sample Performance Tasks - Specific for Unit 1</u>:
SWBAT...

- Obtain, evaluate, and communicate information about the cause and effect relationship between diet and nutrition as they relate to the hierarchical structural organization and function of the digestive system. (**HS-LS1-3, HS-LS1-6)**
- Develop and use a model of the cell membrane to explain how its structure relates to its function in determining mechanisms of cell transport allowing the cell to remain alive as external conditions change.(**HS-LS1-2, HS-LS1-3)**
- Plan and conduct an investigation of the mechanism and control of the cell cycle in order to explain how it relates to stability and change of a complex organism. (**HS-LS1-4)**
- Construct an explanation based on evidence on how the structure and function of a protein is dependent on the genetic information in the DNA sequence. **(HS-LS1-1)**
- Develop and use a model of a plant and animal cell to explain how its structure relates to its function in determining mechanisms of cell division.(**HS-LS1-2, HS-LS1-3)**

Resources
Core Text: **Suggested Resources:** Amoeba Sisters Videos with worksheets BrainPop Videos with worksheets hhmi.org-Biointeractive https://nj.pbslearningmedia.org/ http://www.nclark.net/Biology Lactase enzyme lab: http://serendip.brynmawr.edu/exchange/waldron/enzymes Cell membrane/Cell transport Model Lab: classrooms.tacoma.k12.wa.us/lincoln/jhoffert/.../Cell-Membrane-Bubble-Lab.pdf?id. Food Pyramids Literature on various diets Plant and Animal Cell Lab

Unit Title: Natural Selection and Evolution

Content Area: Science

Course & Grade Level: ESL Biology 9-12

Summary and Rationale

Natural Selection and Evolution helps students formulate an answer to the question, "What evidence shows that different species are related? The LS4 Disciplinary Core Idea involves four sub-ideas: Evidence of Common Ancestry and Diversity, Natural Selection, Adaptation, and Biodiversity. Students can construct explanations for the processes of natural selection and evolution and communicate how multiple lines of evidence support these explanations. Students can evaluate evidence of the conditions that may result in new species and understand the role of genetic variation in natural selection. Additionally, students can apply concepts of probability to explain trends in populations as those trends relate to advantageous heritable traits in a specific environment. The crosscutting concepts of cause and effect and systems and system models play an important role in students' understanding of the evolution of life on Earth.

Recommended Pacing

4-5 weeks

NGSS Standards/Performance Expectations

Standard	
HS-LS4-1	Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]
HS-LS4-2	Construct an explanation based on evidence that the process of evolution primarily results from four factors: (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. [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [*Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.*]
HS-LS4-3	Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tends to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [*Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.*]

HS-LS4-4	Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading 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. [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

Instructional Focus

Unit Enduring Understandings

- Patterns: Variation exists amongst members of a population. Observing patterns of traits, DNA, or amino acid sequences guide the understanding of evolution.
- Cause and effect: The relationship between genetic variation and the selection of traits that provide comparative advantages will result in the evolution of a population.
- Stability and change: Biotic and abiotic factors influence which variations are favored and passed on to subsequent generations within a population.

Unit Essential Questions

- How do we know evolution occurs?
- Can we individually evolve?
- What is the mechanism by which evolution occurs?
- What does the term “fitness” mean?
- Why do some organisms go extinct and others survive?
- What evidence shows that different species are related?
- Do the fittest always survive?
- Is evolution happening now?
- How does speciation occur?
- What are the different pieces of evidence for evolution?
- How does DNA play a role in evolution?
- How do mutations play a role in evolution?
- What causes variation? Can natural selection happen without variation?

Content Statements

Evidence of Common Ancestry and Diversity

- Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.

Natural Selection

- Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2),(HS-LS4-3)
- The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.

Adaptation

- Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.
- Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.
- Adaptation also means that the distribution of traits in a population can change when conditions change.
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species.
- Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.

<u>General for all Units</u>:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop technological literacy and an understanding of the role of information technologies in modern scientific endeavors.
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematics and computational thinking to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomena.
- Construct explanations and design solutions for complex real world environmental problems.

<u>Sample Learning Objectives Specific for Unit 2</u>:

SWBAT…

- Evaluate evidence to explain how evolution occurs through natural selection.
- Interpret data to explain how lines of evidences support evolutionary theory.
- Compare and contrast Darwin and Lamarck and explain why Darwin's theories are still accepted today.

- Give examples of selective pressures that can result in changes in the genetic makeup of a population (e.g. peppered moth, Galapagos finches or pocket mice).
- Develop and use models, such as phylogenetic trees and cladograms to analyze the evolution of organisms based on anatomical traits/DNA/amino acid sequences.
- Differentiate between variation and adaptation.
- Explain how mutations play a role in evolution.
- Cite evidence to prove humans share a common ancestor with primates.
- Differentiate between divergent and convergent evolution citing pieces of evidence for evolution.
- Use claims, data (e.g., fossil record, DNA, protein structures, etc.), and reasoning to construct a scientific explanation for the history of life on Earth.

Sample Performance Tasks - Specific for Unit 2

- Construct an explanation based on evidence that the process of evolution results from adaptation, heritable variation, competition and survival of the fittest. **(HS-LS4-2)**
- Analyze and interpret data from DNA sequence, anatomical structures, embryological similarities and fossil records to identify common ancestry as it supports biological evolution. **(HS-LS4-1)**
- Engage in argument from evidence to compare mechanisms of Lamarck's theory of evolution with Darwin's theory of natural selection. **(HS-LS4-2, HS-LS4-4)**
- Construct an explanation based on evidence that antibiotic resistance occurs due to the process of evolution and adaptation. **(HS-LS4-2)**

Resources

Core Text:

Suggested Resources:

Amoeba Sisters Videos with worksheets
BrainPop Videos with worksheets
Pocket mouse Evolution- http://www.hhmi.org/biointeractive/pocket-mouse-evolution
Weird Organism Project
Evidence for Evolution Lab

Unit Title: Inheritance and Variation of Traits

Content Area: Science

Course & Grade Level: 9-12

Summary and Rationale

Students formulate answers to the questions: "How are characteristics of one generation passed to the next? How can individuals of the same species and even siblings have different characteristics?" Students are able to ask questions, make and defend a claim, and use concepts of probability and an understanding of the events in meiosis to explain the genetic variation in a population. Students demonstrate understanding of why individuals of the same species vary in how they look, function, and behave. Students can explain the mechanisms of genetic inheritance and describe the environmental and genetic causes of gene mutation and the alteration of gene expression.

Recommended Pacing

5-6 weeks

NGSS Standards/Performance Expectations

Standard	
HS-LS1-4	Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. [*Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.*]
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. [*Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.*]
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. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]
HS-LS3-3	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] [*Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.*]

Instructional Focus

Unit Enduring Understandings

- Meiosis is the process that ensures genetic diversity and continuity whereas mitosis works to maintain genetic consistency and continuity**.**
- Sorting and recombination of genes in sexual reproduction result in a great variety of possible gene combinations in the offspring of any two parents

- Inserting, deleting, or substituting DNA segments can alter the genetic code. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm or have little to no effect on the offspring's success in its environment.
- Genetic inheritance usually follows predictable patterns but sometimes real outcomes contradict prediction.

Unit Essential Questions

- Why do individuals of the same species vary in how they look and function?
- How do siblings exhibit different characteristics even though they came from the same parents?
- How do genetic mutations and recombination of genes during meiosis result in variation?
- Why is genetic diversity important to the evolution of a species?
- How are genetic mutations related to DNA?
- How are traits passed from parents to offspring?
- What is the relationship between genotype and phenotype?
- How do scientists predict which genes an organism will inherit?
- To what extent is genetic diversity from generation to generation important?
- To what extent are meiosis and mitosis similar and different?
- Why is evolution essential to the existence of various species?
- What are the implications of genetic engineering on the human race?

Content Statements

Structure and Function

- 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.

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.

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.
- 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.

Ability Objectives

<u>General for all Units</u>:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop technological literacy and an understanding of the role of information technologies in modern scientific endeavors.
- Develop and use models to explain complex processes and relationships between and within organisms.

- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematics and computational thinking to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomena.
- Construct explanations and design solutions for complex real world environmental problems.

Sample Learning Objectives Specific for Unit 3:
SWBAT...

- Model the process of meiosis, by which cells halve their genetic material in order to maintain chromosome numbers in sexual reproduction.
- Demonstrate crossing over and independent assortment and how they lead to genetic variation.
- Explain how variation is introduced in meiosis through the process of crossing over and independent assortment of chromosomes.
- Explain the importance of meiosis.
- Demonstrate how chromosomal abnormalities result from nondisjunction and rearrangement of chromosomes during meiosis.
- Illustrate patterns of inheritance using Punnett Squares.
- Differentiate between Mendelian and Non-Mendelian patterns of inheritance.
- Use pedigrees, karyotypes, and probability analysis to predict genetic outcomes.
- Make and analyze pedigrees for multiple generations.
- Predict the pattern of inheritance of human genetic disorders.
- Differentiate between sexual and asexual reproduction.
- Explain how fertilization restores the diploid number of the next generation.
- Differentiate between genes, DNA and chromosomes.
- Compare and contrast the implications of frameshifts mutations with point and substitution mutations for the production of a protein.
- Explain how environmental factors can affect genes.
- Cite examples of factors that can cause genetic mutations.
- Identify consequences/issues that can result from advances in biotechnology.

Sample Performance Tasks - Specific for Unit 3: SWBAT:

- Model the process of meiosis to identify sources of genetic variation. **(HS-LS3-2)**
- Analyze and interpret genetic data to determine probability and patterns of inheritance of various genetic traits. **(HS-LS3-1, HS-LS3-3)**

Resources

Core Text:
Suggested Resources:
Amoeba Sisters Videos with worksheets
BrainPop Videos with worksheets
hhmi.org-Biointeractive
Meiosis bead lab
Genetic Disorder project
Karotype Analysis
Pedigree Problems
Genetic mutations activity

Unit Title: Matter and Energy in Organisms and Ecosystems

Content Area: Science

Course & Grade Level: 9-12

Summary and Rationale

Students answer the questions: "How do organisms obtain and use energy they need to live and grow? How do matter and energy move through ecosystems?" High school students can construct explanations for the role of energy in the cycling of matter in organisms and ecosystems. Students can develop and analyze models to support and communicate explanations of the interactions of photosynthesis and cellular respiration.
Students understand the interaction of organisms with each other and their physical environment. Students will also understand how organisms obtain resources and how changes in the environment affect ecosystems.

Recommended Pacing

4-5 weeks

NGSS Standards/Performance Expectations

Standard	
HS-LS1-5	Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps.*]
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. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]
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. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [*Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.*]
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. [Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [*Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.*]

HS-LS2-4	Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [*Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy*.]
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. [Clarification Statement: Examples of models could include simulations and mathematical models.] [*Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.*]

Instructional Focus

Unit Enduring Understandings

- Chemical elements are combined into different products as matter cycles and energy flows through different levels of organization within and between living systems and the physical environment.
- Continual input of energy from sunlight keeps matter and energy moving through ecosystems
- Each recombination of matter and energy results in the storage and dissipation of energy into the environment as heat.
- ATP is the universal energy molecule in living things.
- Balance in living systems is maintained by the cycling of matter and the transfer of energy; disruptions to this balance can affect the stability of an ecosystem and ultimately the biosphere.
- The structure of plants and animals is directly related to acquiring and using energy.
- Energy is lost as it moves up the food web through the trophic levels.
- Plants have the capability to take energy from light to form sugar molecules containing carbon, hydrogen and oxygen.
- All organisms must break the high-energy chemical bonds in food molecules during cellular respiration to obtain the energy needed for life processes.
- Microorganisms and animals have the ability to produce ATP in an oxygen deficient environment.
- Photosynthesis and cellular respiration are essential components of the carbon cycle.

Unit Essential Questions

- Can life exist without the sun?
- What's the difference in the ways matter and energy is transferred?
- How is matter transferred and energy transferred/ transformed in living systems?
- What is the role of photosynthesis and cellular respiration in the carbon cycle?
- How is energy utilized in organisms?
- Do plants "breathe"?
- How is energy lost as we move up the trophic levels of a food chain or web?
- What happens in animals and microorganisms when there is a lack of oxygen? How is ATP produced?
- How is balance in living systems maintained by the cycling of matter and the transfer of energy?

Content Statements

- **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.
  - 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.
  - As matter cycles and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
  - 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.

Cycles of Matter and Energy Transfer in Ecosystems

- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- Plants and/or algae form the lowest level of the food web. At each trophic level in a food web, only a small fraction of the matter consumed at the lower level is transferred to the next trophic level, 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.
- 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.

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.

Ability Objectives

<u>General for all Units</u>:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop technological literacy and an understanding of the role of information technologies in modern scientific endeavors.
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematics and computational thinking to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomena.
- Construct explanations and design solutions for complex real world environmental problems.

Sample Learning Objectives Specific for Unit 4:

SWBAT…

- Differentiate between the way matter and energy are transferred in an ecosystem.
- Model and explain the interdependent cyclical relationship between photosynthesis and cell respiration.
- Distinguish between energy production in aerobic and anaerobic cell respiration.
- Identify plant organelles involved in photosynthesis and relate their structure to their function.
- Relate the structure of the chloroplast to its roles in photosynthesis.
- Relate the structure of the mitochondrion to its roles in cell respiration.
- Compare and contrast the internal structure of chloroplasts and mitochondria.
- Predict consequences of removing a species from a food web.
- Explain why ATP is the universal energy molecule and identify its role in biological activity.
- Construct food chains/food webs and label the different trophic labels.
- Explain how organisms can occupy more than one trophic level in a food web.
- Construct a scientific argument using evidence to explain how the transfer and transformation of matter and energy links organisms to one another and to their physical setting.
- Explain the importance of decomposers to an ecosystem?
- Explain how environmental factors can affect the rate of photosynthesis.

Sample Performance Tasks - Specific for Unit 4: SWBAT:

- 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-LS2-5)**
- Develop a model to support the claim that matter is conserved and cycled with an ecosystem. **(HS-LS2-3, HS-LS-4)**
- Using food chains and food webs, construct and revise an explanation based on evidence for the flow of energy within ecosystems. **(HS-LS2-3)**
- Design and carry out an experiment to demonstrate the process of cellular respiration.(**HS-LS2-4, HS-LS2-5)**
- Develop a model to support the claim that energy is lost within an ecosystem. **(HS-LS2-3, HS-LS-4)**
- Design an experiment to demonstrate the relationship between cellular respiration and photosynthesis..(**HS-LS2-4, HS-LS2-5)**

Resources

Amoeba Sisters Videos with worksheets
BrainPop Videos with worksheets
hhmi.org-Biointeractive
Snail and Elodea Lab
Ginger Ale Lab
Exercise Lab
Yeast Lab

Unit Title: Interdependent Relationships in Ecosystems

Content Area: Science

Course & Grade Level: 9-12

Summary and Rationale

Students answer the question, "How do organisms interact with the living and nonliving environment?" This topic builds on the other topics as high school students demonstrate an ability to investigate the role of biodiversity in ecosystems and the role of animal behavior on survival of individuals and species. Students have increased understanding of interactions among organisms and how those interactions influence the population dynamics of ecosystems. Specifically, changes in population dynamics can result from human influence. Students can generate mathematical comparisons, conduct investigations, use models, and apply scientific reasoning to link evidence to explanations about interactions and changes within ecosystems.

Recommended Pacing

4 weeks

NGSS Standards/Performance Expectations

Standard	
HS-LS2-1	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]
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. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]
HS-LS2-6	Evaluate the 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. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]
HS-LS2-7	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]
HS-LS2-8	Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. [Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3)

	developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]
HS-LS4-6	Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

Instructional Focus

Unit Enduring Understandings

- All living things are interconnected in an ecosystem.
- The link between the biotic and abiotic components of an ecosystem is demonstrated through the transformation of energy and the cycling of matter.
- Like many complex systems, ecosystems tend to show cyclic fluctuations around a state of approximate equilibrium.
- Changes in the physical environment and human activity can result in fluctuations in populations and species distribution.
- Changes in the number of organisms affect all trophic levels in a food chain or food web.

Unit Essential Questions

- How can change in one part of an ecosystem affect change in other parts of the ecosystem?
- How do our choices affect us, our ecosystem and the biosphere?
- How does climate change have an impact on ecosystems?
- In what ways do species depend on one another and how does that affect their populations?
- How does group behavior affect the survival of a species?
- How does the exponential growth of the human population impact ecosystems on Earth?

Content Statement

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.

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.
- 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.

Social Interactions and Group Behavior

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

Adaptation

- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species.

Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).
- 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.

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.
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

Ability Objectives

<u>General for all Units</u>:

- Develop and carry out scientific investigations.
- Obtain, evaluate and communicate information to develop technological literacy and an understanding of the role of information technologies in modern scientific endeavors.
- Develop and use models to explain complex processes and relationships between and within organisms.
- Analyze and interpret data and communicate information using a variety of modalities.
- Use mathematics and computational thinking to support scientific conclusions.
- Engage in argument from evidence to explain natural phenomena.
- Construct explanations and design solutions for complex real world environmental problems.

<u>Sample Learning Objectives Specific for Unit 5:</u>

SWBAT...

- Differentiate between an organism's niche and habitat.
- Explain the different types of intraspecific and interspecific relationships among organisms within an ecosystem.
- Differentiate among the effects of density-dependent and density-independent limiting factors on a population.

- Interpret and predict population growth curves of carrying capacity and exponential growth.
- Given characteristics of an interspecific relationship, determine the type of symbiosis and competition.
- Predict consequences of removing a species from a food web.
- Predict consequences of the exponential growth of the human population.
- Differentiate between the effects of the addition and/or removal of organisms from various trophic levels in a food web.
- Make predictions about how a population will behave in specified circumstances, including the addition or limitation of constraints and resources.

Sample Performance Tasks - Specific for Unit 5: SWBAT:

- Given data, students will develop and use models to explain the cause and effect relationships between and within populations by constructing and/or analyzing growth curve graphs. **(HS-LS2-1)**
- Obtain, evaluate, and communicate information regarding the stability and change of an ecosystem as it relates to a complex set of interactions within an ecosystem. **(HS-LS2-6)**
- Use mathematical and computational data to analyze population growth curves that result from changes in condition that relate to predation, competition, disease and other finite non-living resources. **(HS-LS2-1).**
- Design, evaluate and refine a solution for reducing the impacts of human activities on the environment and biodiversity. **(HS-LS4-6)**
- Construct an explanation for the impact of group behavior on the stability of a species.**(HS-LS2-8)**
- Obtain, evaluate, and communicate information about the cause and effect relationship between adding and removing organisms from different trophic levels

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Resources

Core Text:

Suggested Resources:

Amoeba Sisters Videos with worksheets
BrainPop Videos with worksheets
hhmi.org-Biointeractive

Human Impact Project
Biome Project