BIOLOGY
GRADE 9-12

EWING PUBLIC SCHOOLS
2099 Pennington Road
Ewing, NJ 08618

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In accordance with The Ewing Public Schools' Policy 2230, Course Guides, this curriculum has been reviewed and found to be in compliance with all policies and all affirmative action criteria.

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Course Description and Rationale

Biology at Ewing High School is a laboratory-based approach to the study of life. Biology, like all of the sciences, is a process of discovery. It is a process with an impressive history and an incredible future. The program weaves current research and discoveries with insights made hundreds of years ago. Many of these discoveries will apply to each student's everyday life: biology is closely connected with all aspects of our day-to-day activities. Biology is also closely connected with the decisions students will be making about their future and the future of this planet.

Life is self-contained, self-sustaining, self-replicating and evolving, operating according to laws of the physical world, as well as genetic programming. Life scientists use observations, experiments, hypotheses, tests, models, theory and technology to explore how life works. The study of life ranges over scales from single molecules, through organisms and ecosystems, to the entire biosphere, that is all life on Earth. It examines processes that occur on time scales from the blink of an eye to those that happen over billions of years. Living systems are interconnected and interacting. Although living organisms respond to the physical environment or geosphere, they have also fundamentally changed Earth over evolutionary time. Rapid advances in life sciences are helping to provide biological solutions to societal problems related to food, energy, health and environment.

From viruses and bacteria to plants to fungi to animals, the diversity of the millions of life forms on Earth is astonishing. Without unifying principles, it would be difficult to make sense of the living world and apply those understandings to solving problems. A core principle of the life sciences is that all organisms are related by evolution and that evolutionary processes have led to the tremendous diversity of the biosphere. There is diversity within species as well as between species. Yet what is learned about the function of a gene or a cell or a process in one organism is relevant to other organisms because of their ecological interactions and evolutionary relatedness. Evolution and its underlying genetic mechanisms of inheritance and variability are key to understanding both the unity and the diversity of life on Earth.

The course is built on four disciplinary core ideas:

- The first core idea, LS1: From Molecules to Organisms: Structures and Processes, addresses how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction. The first core idea hinges on the unifying principle that cells are the basic unit of life.

- The second core idea, LS2: Ecosystems: Interactions, Energy and Dynamics, explores organisms' interactions with each other and their physical environment. This includes how organisms obtain resources, how they change their environment, how changing environmental factors affect organisms and ecosystems, how social interactions and group behavior play out within and between species and how these factors all combine to determine ecosystem functioning.

- The third core idea, LS3: Heredity: Inheritance and Variation of Traits across generations, focuses on the flow of genetic information between generations. This idea explains the mechanisms of genetic inheritance and describes the environmental and genetic causes of gene mutation and the alteration of gene expression.

- The fourth core idea, LS4: Biological Evolution: Unity and Diversity, explores 'changes in the traits of populations of organisms over time' and the factors that account for species' unity and diversity alike. The section begins with a discussion of the converging evidence for shared ancestry that has emerged from a variety of sources (e.g., comparative anatomy and embryology, molecular biology and genetics). It describes how variation of genetically-determined traits in a population may give some members a reproductive advantage in a given environment. This natural selection can lead to adaptation, that is, to a distribution of traits in the population that is matched to and can change with environmental conditions. Such adaptations can eventually lead to the development of separate species in separated populations. Finally, the idea describes the factors, including human activity, that affect biodiversity in an ecosystem and the value of biodiversity in ecosystem resilience.

Students use the eight NGSS Science and Engineering Practices to demonstrate understanding of the disciplinary core ideas:

- Asking questions (science) and defining problems (engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using math and computational thinking
- Constructing explanations (science) and designing solutions (engineering)
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

The following seven cross-cutting concepts support the development of a deeper understanding of the disciplinary core ideas:

- Patterns
- Cause and effect: mechanism and explanation
- Scale, proportion and quantity
- Systems and system models
- Energy and matter: flows, cycles and conservation
- Structure and function
- Stability and change

The course follows a block semester schedule, with students meeting daily for 88 minutes. The course content is arranged into five units of study:

In **Unit 1: Introduction to Biology**, students investigate the characteristics common to all living things and construct explanations for the structure and functions of cells as the basic unit of life and of hierarchical organization within living systems. Students also gain experience using the eight NGSS Science and Engineering Practices that will be used to demonstrate understanding of disciplinary core ideas in all subsequent units.

In **Unit 2: Matter and Energy in Organisms**, students plan and conduct investigations related to how plants and animals interact to effectively monitor and respond to both internal and external environmental changes and acquire the energy necessary for the processes of life. Students develop and use models to illustrate processes that occur in the human body in order to maintain homeostasis, including gas exchange, glucose regulation, thermoregulation, and maintaining water balance. They apply mathematical concepts to develop evidence to support explanations of the interactions of photosynthesis and cellular respiration and they will develop models to communicate these explanations.

In **Unit 3: Evolution**, students construct explanations and design solutions, analyze and interpret data and engage in argument from evidence to investigate to make sense of the relationship between the environment and natural selection. Students also develop an understanding of the factors causing natural selection of species over time. They also demonstrate and understand how multiple lines of evidence contribute to the strength of scientific theories of natural selection. Students construct explanations for the processes of natural selection and evolution and then communicate how multiple lines of evidence support these explanations. Students 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 population as those trends relate to advantageous inheritable traits in a specific environment.

In **Unit 4: Heredity and Reproduction**, students analyze data and develop models to make sense of the relationship between DNA and chromosomes in the process of cellular division, which passes traits from one generation to the next. Students determine why individuals of the same species vary in how they look, function and behave. Students develop conceptual models of the role of DNA in the unity of life on Earth and use statistical models to explain the importance of variation within populations for the survival and evolution of species. Ethical issues related to genetic modification of organisms and the nature of science are described. Students explain the mechanisms of genetic inheritance and describe the environmental and genetic causes of gene mutation and the alteration of gene expressions.

In **Unit 5: Ecology**, students use mathematical reasoning and models to make sense of carrying capacity, factors affecting biodiversity and populations, the cycling of matter and flow of energy through systems. Students also understand organisms' interactions with each other and their physical environment and how organisms obtain resources. Mathematical models provide support for students' conceptual understanding of systems and students' ability to design, evaluate and refine solutions for reducing the impact of human activities on the environment and maintaining biodiversity. Students create or revise a simulation to test solutions for mitigating adverse impacts of human activity on biodiversity.

Career Readiness, Life Literacies, and Key Skills

During this course, students will work on developing, to an age appropriate level, the following Career Readiness, Life Literacies, and Key Skills:

Disciplinary Concepts:

- Career Awareness and Planning
  - An individual's strengths, lifestyle goals, choices, and interests affect employment and income.
  - Developing and implementing an action plan is an essential step for achieving one's personal and professional goals.
  - Communication skills and responsible behavior in addition to education, experience, certifications, and skills are all factors that affect employment and income.
- Creativity and Innovation
  - Gathering and evaluating knowledge and information from a variety of sources, including global perspectives, fosters creativity and innovative thinking.
- Critical Thinking and Problem-solving
  - Multiple solutions exist to solve a problem.
  - An essential aspect of problem solving is being able to self-reflect on why possible solutions for solving problems were or were not successful.
- Digital Citizenship
  - Detailed examples exist to illustrate crediting others when incorporating their digital artifacts in one's own work.
  - Digital communities are used by Individuals to share information, organize, and engage around issues and topics of interest.
  - Digital technology and data can be leveraged by communities to address effects of climate change.
- Global and Cultural Awareness
  - Awareness of and appreciation for cultural differences is critical to avoid barriers to productive and positive interaction.
- Information and Media Literacy
  - Increases in the quantity of information available through electronic means have heightened the need to check sources for possible distortion, exaggeration, or misrepresentation.

- Digital tools make it possible to analyze and interpret data, including text, images, and sound. These tools allow for broad concepts and data to be more effectively communicated.
- Sources of information are evaluated for accuracy and relevance when considering the use of information.
- There are ethical and unethical uses of information and media.

- Technology Literacy
  - Some digital tools are appropriate for gathering, organizing, analyzing, and presenting information, while other types of digital tools are appropriate for creating text, visualizations, models, and communicating with others. • Digital tools allow for remote collaboration and rapid sharing of ideas unrestricted by geographic location or time.

Technology Integration

<u>Computer Science and Design Thinking</u>

During this course, students will work on developing, to an age appropriate level, the following Computer Science and Design Thinking Skills:

Disciplinary Concepts and Core Ideas:

- Data & Analysis
  - People use digital devices and tools to automate the collection, use, and transformation of data.
  - The manner in which data is collected and transformed is influenced by the type of digital device(s) available and the intended use of the data.
  - Data is represented in many formats. Software tools translate the low-level representation of bits into a form understandable by individuals. Data is organized and accessible based on the application used to store it.
  - The purpose of cleaning data is to remove errors and make it easier for computers to process.
  - Computer models can be used to simulate events, examine theories and inferences, or make predictions.

- Engineering Design
  - Engineering design is a systematic, creative and iterative process used to address local and global problems.
  - The process includes generating ideas, choosing the best solution, and making, testing, and redesigning models or prototypes.
  - Engineering design requirements and specifications involve making trade-offs between competing requirements and desired design features.
- Interaction of Technology and Humans
  - Economic, political, social, and cultural aspects of society drive development of new technological products, processes, and systems.
  - Technology interacts with society, sometimes bringing about changes in a society's economy, politics, and culture, and often leading to the creation of new needs and wants.
  - New needs and wants may create strains on local economies and workforces.
  - Improvements in technology are intended to make the completion of tasks easier, safer, and/or more efficient.
- Nature of Technology
  - Technology advances through the processes of innovation and invention which relies upon the imaginative and inventive nature of people.
  - Sometimes a technology developed for one purpose is adapted to serve other purposes.
  - Engineers use a systematic process of creating or modifying technologies that is fueled and constrained by physical laws, cultural norms, and economic resources. Scientists use systematic investigation to understand the natural world.
- Effects of Technology on the Natural World
  - Resources need to be utilized wisely to have positive effects on the environment and society.
  - Some technological decisions involve trade-offs between environmental and economic needs, while others have positive effects for both the economy and environment.

ELA Integration:

NJSLS.RST.9-10.8. Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem
NJSLS.RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

NJSLS.RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
NJSLS.RST.11-12.8 Evaluate the hypotheses, data, analysis and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
NJSLS.SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning and well-chosen details; use appropriate eye contact, adequate volume and clear pronunciation.
NJSLS.SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual and interactive elements) in presentations to enhance understanding of findings, reasoning and evidence and to add interest.
NJSLS.WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
NJSLS.WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
NJSLS.WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection and research.
NJSLS.WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Math Integration:

NJSLS.MP.2 Reason abstractly and quantitatively.
NJSLS.MP.4 Model with mathematics.
NJSLS.HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
NJSLS.HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
NJSLS.HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
NJSLS.HSS-IC.A.1Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
NJSLS.HSS-ID.A.1Represent data with plots on the real number line.

Unit 1: Introduction to Biology (2 Weeks)

Why Is This Unit Important?

This unit serves to define the scope of the biology course and introduce students to the characteristics common to all living organisms. The unit also serves as an introduction to the NGSS Science and Engineering Practices, laying the foundation for the essential skills that will be used and assessed repeatedly throughout the semester.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **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.

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)

Science and Engineering Practices:

Developing and Using Models

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-2)

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)

Cross Cutting Concepts:

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)

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)

Enduring Understandings:

- Systems of specialized cells within organisms help them perform the essential functions of life (HS-LS1-1)
- 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).

Essential Questions:

- What does it mean to be alive?
- How is life organized and maintained?
- Why is homeostasis important to all living things?

Acquired Knowledge:

- Provide examples and explain the characteristics common to all organisms.
- Relate the hierarchical levels of biological organization from the simplest (i.e., subatomic particles) to the most complex (i.e., biosphere).
- Provide examples and explain how organisms use feedback systems to maintain their internal environments.

Acquired Skills:

- Asking scientific questions
- Developing and using models
- Planning and carrying out investigations
- Analyzing data and graphing
- Constructing scientific explanations
- Generating scientific arguments based on evidence

Assessments:

Formative Assessments:

- Group discussions/presentations:
    - Propose higher order questions
    - Present information to students and ask a question
    - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Homeostasis Inquiry Lab: Students design and carry out a controlled experiment to determine the relationship between environmental stimuli (e.g., exercise, temperature) and physiological response (e.g., heart rate, respiration rate).

Benchmarks:

- Students will be assessed on their ability to plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Alien Invaders (data analysis and constructing explanations)
- The Checks (hypothesis testing and evaluation)
- Petals around the rose (data analysis and constructing explanations)
- How to lose at tic tac toe
- Sorting species cards activity
- Charty party (graphing game)

In-Class Activities and Laboratory Experiences:

- Should Viruses Be Classified as Living Things? (argumentation from Evidence performance assessment)
- Scientific Method Internet activity
- Cell Microscopy Lab
- Webquest: Cells Alive
- Practice Graphing Data
- Effect of Exercise on Heart Rate Lab
- Effect of Water Temperature on Goldfish Respiration Rate Lab
- POGIL Activities:
    - Scientific Inquiry
    - Experimental Variables
    - Analyzing and Interpreting Scientific Data
    - Prokaryote and Eukaryote Cells
    - Organelles in Eukaryote Cells
- Gizmos
    - Paramecium Homeostasis
    - Circulatory System
    - Human Homeostasis
    - Homeostasis STEM Case
- Classifying organisms with dichotomous keys

Closure and Reflection Activities:

- Student Discussion
- Journal Response (Arguing from Evidence)
- Exit Tickets

Instructional Materials:

- Canvas
- Calculators
- Computers with internet access, word processor and a spreadsheet
- Projector for teacher's computer or a Smartboard
- POGIL Biology
- Microscopes

Technology Connections:

- Gizmos (http://gizmos.explorelearning.com)
- Cells alive (http://www.cellsalive.com/cells/)

Unit 2: Matter and Energy in Organisms (4 Weeks)

Why Is This Unit Important?

Living systems require free energy and matter to maintain order, grow and reproduce. Organisms employ various strategies to capture, use and store free energy and other vital resources. Energy deficiencies are not only detrimental to individual organisms; they also can cause disruptions at the population and ecosystem levels.

Cells and organisms must exchange matter with the environment. For example, water and nutrients are used in the synthesis of new molecules; carbon moves from the environment to organisms where it is incorporated into carbohydrates, proteins, nucleic acids or fats; and oxygen is necessary for more efficient free energy use in cellular respiration. Differences in surface-to-volume ratios affect the capacity of a biological system to obtain resources and eliminate wastes.

Autotrophic cells capture free energy through photosynthesis and chemosynthesis. Photosynthesis traps free energy present in sunlight that, in turn, is used to produce carbohydrates from carbon dioxide. Chemosynthesis captures energy present in inorganic chemicals. Cellular respiration and fermentation harvest free energy from sugars to produce free energy carriers, including ATP. The free energy available in sugars drives metabolic pathways in cells. Photosynthesis and respiration are interdependent processes.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-LS1-2:** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- **HS-LS1-5:** 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 broke and the bonds in new compounds are formed, resulting in a net transfer of energy.
- **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-ETS1-2:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Disciplinary Core Ideas:

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)

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)

Science and Engineering Practices:

Developing and Using Models

- Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-5),(HS-LS1-7)

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena or design solutions to support claims. (HS-LS2-4)

Constructing Explanations and Designing Solutions

- Construct and revise 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-LS1-6),(HS-LS2-3)

Cross Cutting Concepts:

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),(HS-LS2-4)
- Energy drives the cycling of matter within and between systems. (HS-LS2-3)

Enduring Understandings:

- 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).
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes (HS-LS2-3)
- 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).
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Essential Questions:

- How do organisms interact with the living and nonliving environment to obtain matter and energy?
- Can life exist without the sun?
- Do plants 'breathe'?
- Why do we eat what we eat?
- How do we get energy from the food we eat?

Acquired Knowledge:

- Identify the elements found in carbohydrates, lipids, proteins and nucleic acids.
- Describe the changes in free energy associated with anabolic and catabolic chemical reactions.
- Explain how glucose and ATP can provide the raw materials and energy needed to synthesize other biomolecules.
- Describe how carbon dioxide and water are produced from sugar and oxygen by the process of cellular respiration.
- Describe the steps of anaerobic vs. aerobic cellular respiration.
- Relate the availability of oxygen to the net production of ATP by cellular respiration.
- Explain why fermentation is necessary to keep glycolysis going under anaerobic conditions.
- Explain how the structure of the leaf supports its function as a site of photosynthesis.
- Describe how glucose and oxygen gas are produced during photosynthesis.
- Describe how chloroplasts capture light energy and transfer it into chemical energy.
- Describe how the structure of ATP relates to its function as the energy currency of the cell.
- Describe how autotrophs and heterotrophs obtain energy from their environments.
- Describe how at least two major body systems interact to provide specific functions in multicellular organisms:
  - Digestive and circulatory system → delivering sugars to cells
  - Circulatory and respiratory systems → gas exchange
- Account for inefficiencies in the transfer of matter and energy.

Acquired Skills:

- Justify the claim that cellular respiration converts the energy stored in food molecules into energy that is available to do work in cells.
- Use a model to explain how electron transport chains in the mitochondrion and/or chloroplast provide the energy needed to make ATP.
- Use a model of the carbon cycle to explain the relationship between photosynthesis and cellular respiration.
- Use experimental data to evaluate the claim that plants consume oxygen gas and produce carbon dioxide gas as waste just as animals do.

Assessments:

Formative Assessments:

- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Enzyme Rate Inquiry Lab:- Students collect and analyze data to determine the changes to reaction rate over the course of an enzyme-controlled chemical reaction. The guided investigation provides baseline data for a follow-up inquiry investigation. Possible independent variables include substrate concentration, enzyme concentration, temperature, pH and the presence of competitive or noncompetitive inhibitors.
- Cellular Respiration and Photosynthesis Modeling: - Students construct a model to illustrate the movement of matter and energy in photosynthesis and/or cellular respiration.

Benchmarks:

- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
- Students will be assessed on their ability to use a model to illustrate how photosynthesis transforms light energy into stored chemical
- Students will be assessed on their ability to develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- Students will be assessed on their ability to use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
- Students will be assessed on their ability to develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere and geosphere.
- Students will be assessed on their ability to design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Alternative Assessments:

- Modified project requirements and rubric

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Blood Glucose Data Analysis (http://www.hhmi.org/biointeractive/got-lactase-blood-glucose-data-analysis)
- Exercise and Respiration Lab
- Brewer's Dilemma
- The Plant Game
- Video: Guts

In-Class Activities and Laboratory Experiences:

- HONC bonding activity
- Carbohydrate modeling lab
- Reagent testing lab
- Enzymes in Action modeling activity
- Rate of Toothpickase/Paperase Lab
- Digestive System Modeling Lab
- Rat Dissection
- Membrane Permeability Inquiry Lab
- Yeast Fermentation Inquiry Lab
- Leaf Structure and Function Lab
- Plant Pigment Chromatography Lab
- Photosynthesis Rate Lab (e.g., Floating Leaf Disk Assay)
- Photosynthesis and Respiration Inquiry Lab with Argumentation
- POGIL Activities:
    - Biological Molecules
    - Membrane Structure and Function
    - Transport in Cells
    - Photosynthesis - what's in a Leaf
    - Cellular Respiration
    - Photosynthesis and Respiration
    - Gizmos
    - Human Digestive System
    - Enzymes STEM Case
    - Cell Energy Cycle
    - Cellular Respiration STEM Case
    - Photosynthesis Lab
    - Photosynthesis STEM Case
    - Plants and Snails

Closure and Reflection Activities:

- Food Label Analysis
- Cellular Respiration Matter & Energy Models
- Photosynthesis Matter & Energy Models

Instructional Materials:

- Canvas
- Calculators
- Computers with internet access, word processor and a spreadsheet
- Projector for teacher's computer or a Smartboard
- POGIL Biology
- Microscope
- Modeling kits

Technology Connections:

- Gizmos (http://gizmos.explorelearning.com)
- Next Generation Science Storylines (https://www.nextgenstorylines.org/)
- HHMI Photosynthesis animation
- Enzyme animations (http://www.lpscience.fatcow.com/jwanamaker/animations/Enzyme%20activity.html)
- Respiration animations (http://www.sumanasinc.com/webcontent/animations/content/cellularrespiration.html)
- Photosynthesis animations:
    - Light reactions (http://www.science.smith.edu/departments/Biology/Bio231/ltrxn.html)
    - Calvin cycle (http://www.science.smith.edu/departments/Biology/Bio231/calvin.html)

Unit 3: Evolution (3-4 Weeks)

Why Is This Unit Important?

This unit will establish the idea of evolution as the underlying and unifying theme of all areas of study in biology. Evolution is like a thread, running through the fabric of biological inquiries and uniting seemingly diverse topics, such as molecular biology, genetics, structure and function in living things, ecology and cellular biology, to name just a few. Big ideas in this unit include a) understanding how evolutionary mechanisms (e.g., natural selection and sexual selection) lead to changes in populations (microevolution) as well as the formation of new species (macroevolution); and b) the plethora of evidence that supports the relatedness of all living organisms.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-LS3-3:** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
- **HS-LS4-1:** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
- **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.
- **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-LS2-8**: Evaluate evidence for the role of group behavior on individual and species’ chances to survive and reproduce.

Disciplinary Core Ideas:

LS4.A: 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. (HS-LS4-1)

LS4.B: 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. (HS-LS4-3)

LS4.C: 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. (HS-LS4-2)
- 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. (HS-LS4-3),(HS-LS4-4)
- Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)
- 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. (HS-LS4-5)
- 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. (HS-LS4-5)

Science and Engineering Practices:

Analyzing and Interpreting Data

- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (HS-LS4-3)

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-LS4-2),(HS-LS4-4)

Engaging in Argument from Evidence

- Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS4-5)

Obtaining, Evaluating, and Communicating Information

- Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-LS4-1)

Cross Cutting Concepts:

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-LS4-1),(HS-LS4-3)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-2),(HS-LS4-4),(HS-LS4-5)

Enduring Understandings:

- Genetic information 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 (HS-LS4-1).
- 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 (HS-LS4-3)
- 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 the environment (HS-LS4-2)

- 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 that trait and to a decrease in the proportion of individuals that do not (HS-LS4-3, HS-LS4-4)
- Adaptation also means that the distribution of traits in a population can change when conditions change (HS-LS4-3)
- Changes in the physical environment, whether naturally occurring or human induces, 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 (HS-LS4-5, HS-LS4-6)
- 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 of the species' evolution is lost (HS-LS4-5).
- Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives (HS-LS2-8).

Essential Questions:

- How can there be so many similarities among organisms yet so many different kinds of plants, animals and microorganisms?
- What evidence shows that different species are related?
- How do we know evolution happens?
- Why do some traits lead to differential survival?
- Is evolution happening now?
- Do all species adapt to their environment?

Acquired Knowledge:

- Describe how fossil records provide evidence of evolution.
- Compare the evolutionary relationship of ancient and present living organisms based on anatomical and embryological similarities.
- Compare DNA/amino acid sequence of different organisms to infer evolutionary relationships.
- Justify the claim that common ancestry and biological evolution are supported by multiple lines of evidence.
- Justify the claim that most species produce more offspring than can possibly survive.
- Connect variations in expressed traits to heritable genetic variation due to mutation and sexual reproduction.
- Provide examples of competition for limited resources.
- Explain why individuals with traits that confer competitive advantages are more likely to survive and reproduce in the environment.

- Compare and contrast natural and sexual selection as mechanisms of evolution.
- Determine patterns of change in the distribution of traits in a population over time (e.g., peppered moth).
- Explain how natural selection results in a population that is better suited for the environment.
- Identify selection pressure and adaptation, given an example.
- Explain how reproductive isolation can lead to the formation of a new species.

Acquired Skills:

- Examine a group of related organisms using a phylogenetic tree or cladogram in order to:
    - identify shared characteristics
    - make inferences about the evolutionary history
    - identify character data that could extend or improve the phylogenetic tree
- Use data as evidence to support claims about the positive or negative effects on survival and reproduction of individuals with a given trait.
- Interpret evidence to determine which species is better adapted for a particular environment.
- Evaluate data to determine the correlation between environmental disturbances and loss of species.

Assessments:

Formative Assessments:

- Group discussions/presentations:
    - Propose higher order questions
    - Present information to students and ask a question
    - Have students discuss their answers with their peers at their table and discuss together as a group
- Natural selection concept inventory

Summative Assessments:

- Natural Selection Simulation Lab: Students collect and analyze data to show changes in the frequency of a trait in a population over time. The data serves as evidence for a scientific explanation about the causal mechanism of the change. Darwin and Wallace's theory of natural selection provides the reasoning that links the evidence to the claim.
- Evolutionary Relationships Modeling & Argumentation: - Students analyze evidence for evolution (e.g., amino acid sequence comparisons) to construct a model for the proposed evolutionary patterns linking a group of species (i.e., cladogram or phylogenetic tree). The initial model serves as a testable hypothesis when additional evidence for evolution is introduced; students may confirm or revise their model based on the new evidence. Ultimately, students generate an argument about the evolutionary relationships based on the evidence for evolution.

Benchmarks:

- Students will be assessed on their ability to apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
- Students will be assessed on their ability to 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
- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to construct an explanation based on evidence for how natural selection leads to adaptation of populations.
- Students will be assessed on their ability to communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
- Students will be assessed on their ability to 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.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Almond Variation Lab
- Evolution Pre-Assessment

In-Class Activities and Laboratory Experiences:

- Natural selection simulations:
  - Beaks of the Finches Lab
  - Peppered moth simulation
  - Jelly bean evolution
  - Straw Birds
- Guppy Evolution Game (natural vs. sexual selection pressures)
- Biochemical Evidence and Cladograms
- Whale evolution
- Timeline of life on earth
- Examining the Fossil Record Lab (gradualism vs. punctuated equilibrium)
- Lizard Island Biogeography Lab
- HHMI Activities
  - Color Variation of Rock Pocket Mice
  - Lizards in an Evolutionary Tree
- POGIL Activities:
  - Evidence for Evolution
  - Evolution and Selection
- Gizmos
  - Rainfall and Bird Beaks
  - Natural Selection
  - Evolution STEM Case
  - Hominid Skulls
- Career Exploration: Genetics Counselor
- Gender Expression Project

Closure and Reflection Activities:

- Understanding Natural Selection (practice explaining how species acquire certain adaptations, such as the giraffe's long neck)
- Evidence for Evolution Review Stations
- Video: Galapagos (looking for evidence and mechanism of evolution)

Instructional Materials:

- Canvas
- Calculators
- Computers with internet access, word processor and a spreadsheet
- Projector for teacher's computer or a Smartboard
- POGIL Biology

Technology Connections:

- Gizmos (http://gizmos.explorelearning.com)
- Next Generation Science Storylines (https://www.nextgenstorylines.org/)
- HHMI Videos:
  - The Origin of Species: The Making of a Theory (http://www.hhmi.org/biointeractive/origin-species-making-theory)
  - The Origin of Species: Lizards in an Evolutionary Tree

    (http://www.hhmi.org/biointeractive/origin-species-lizards-evolutionary-tree)
- Virtual Activities:
  - Recent Adaptations in Humans (http://www.hhmi.org/biointeractive/recentadaptations-human)
  - Human Evolution Timeline Interactive

    (http://humanorigins.si.edu/evidence/human-evolution-timeline-interactive)
  - Peppered Moth Simulation (http://peppermoths.weebly.com/)

Unit 4: Heredity and Reproduction (5 Weeks)

Why Is This Unit Important?

Darwin had a fundamental problem with his theory of evolution by means of natural selection. On the one hand, in order for it to work, there had to be variation in offspring. On the other hand, those variations which were environmentally favorable must be able to be passed on to succeeding generations, in order to effect changes in populations. What, then, is the precise mechanism of inheritance that can yield both variation and continuity of traits in offspring?

The only way an organism can grow or heal itself is by cellular reproduction. The timing and rate of cell reproduction are important to the health of an organism. Although the cell cycle has a system of quality control checkpoints, it is a complex process that sometimes fails. When cells do not respond to the normal cell cycle control mechanisms, cancer can result. However, not all cells can be produced via mitosis and cytokinesis. In order to maintain the same chromosome number from generation to generation, sexually reproducing organisms must produce gametes that have half the number of chromosomes of a normal (somatic) cell. Meiosis also explains the basis of the genetic variation that lies at the heart of Darwin's theory of natural selection and enables the long-term survival of species.

The big ideas within this unit are:

- Inheritance involves 'particulate' units; it is not a 'blending' type of process.
- The relationship between physical traits and the genetics that have resulted in them is rarely simple: there are numerous patterns of genetic inheritance.
- The physical appearance and chemistry of an organism is not solely dependent upon the genes it has received; environment plays a large role in an individual's size, structure and overall fitness.
- Genes, when reproduction is occurring, are organized into packets called chromosomes. An understanding of chromosomal inheritance is essential to gaining a thorough knowledge of hereditary patterns.
- DNA codes for RNA, which guides protein synthesis. Proteins are largely responsible for an organism's traits.
- Cells grow until they reach their size limit, then they either stop growing or divide.
- Eukaryotic cells reproduce by mitosis, the process of nuclear division and cytokinesis, the process of cytoplasmic division.
- Reproductive cells, which pass on genetic traits from the parents to the child, are produced by the process of meiosis.
- Genetic variation commonly results from events during meiosis.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **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-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-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-LS1-4:** Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
- **HS-ETS1-3:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Disciplinary Core Ideas:

LS1.A: 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. *(secondary to HS-LS3-1) (Note: This Disciplinary Core Idea is also addressed by HS-LS1-1.)*

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)

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)

Science and Engineering Practices:

Asking Questions and Defining Problems

- Ask questions that arise from examining models or a theory to clarify relationships. (HS-LS3-1)

Developing and Using Models

- Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-4)

Analyzing and Interpreting Data

- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (HS-LS3-3)

Engaging in Argument from Evidence

- Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence. (HS-LS3-2)

Cross Cutting Concepts:

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)

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-LS1-4)

Enduring Understandings:

- 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 (HS-LS3-1)
- 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)
- 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 the expression of traits, and hence 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)
- 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 tissues and organs that work together to meet the needs of the whole organism (HS-LS1-4).

Essential Questions:

- Why do individuals of the same species vary in how they look and function?
- If all living things share the same genetic code, how can there be such a great variety of species?
- How is it that a change in the genetic code can have a benign effect, a deleterious effect, or no effect at all?
- To what extent is genetic diversity from generation to generation important?
- To what extent is genetic constancy from generation to generation important?
- If all of the cells in my body contain the same genetic information, how do different tissues arise?

Acquired Knowledge:

- Explain how the process of meiosis results in the passage of traits from parent to offspring.
- Compare the products of meiosis and mitosis.
- Explain how crossing over during meiosis results in increased genetic diversity.
- Describe how an error in DNA replication can lead to new genetic combinations.
- Provide examples of environmental factors that can cause DNA damage and lead to mutations
- Connect the structural differences between DNA and RNA to their functions in all cells.
- Explain the connection between structure and function in proteins (e.g., enzymes).
- Identify examples of how specialized cells produce proteins that carry out essential life functions.
- Predict the effect of mutations on protein synthesis.
    - Point mutations
    - Frameshift mutations
- Explain the advantage of organizing hereditary information into chromosomes.
- Describe the functions of DNA segments that do not code for proteins.
- Describe what processes occur in each step of the eukaryotic cell cycle.
- Describe how DNA is replicated prior to cell division.
- Explain how cell differentiation leads to the creation of different cell types in a multi-celled

Acquired Skills:

- Construct and interpret pedigrees
- Predict the inheritance of traits using Punnett squares
- Construct a DNA model and label its parts
- Create representations that explain how genetic information flows from a sequence of nucleotides in a gene to a sequence of amino acids in a protein (e.g., transcription, translation)
- Investigate the cause and effect relationships among DNA, RNA, proteins and the traits of an organism.
- Create a visual representation or model to illustrate how mitosis produces two genetically identical daughter cells from one parent cell.
- Create a visual representation or model to illustrate how meiosis produces four genetically unique daughter cells from one parent cell.

Assessments:

Formative Assessments:

- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Virtual Genetics Inquiry Lab with Argumentation: Students investigate the inheritance pattern of fruit fly traits by setting up virtual crosses and analyzing the F1/F2 data. Students then make a claim about how each trait is inherited, using their genetic cross data as evidence and Punnett squares to provide the reasoning linking the data with their claim(s).
- Protein Synthesis & Effects of Mutations Modeling: - Students create a model that shows how a gene gets transcribed and translated into a protein. Students then manipulate their model to illustrate the effects of a mutation (e.g., missense, nonsense, silent, frameshift) on the synthesis of that protein and make a prediction about the overall impact on protein function.
- Cellular Reproduction Modeling: - Students create a model to show how mitosis produces two genetically identical daughter cells from one parent cell and/or how meiosis produces four genetically unique daughter cells from one parent cell.

Benchmarks:

- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
- Students will be assessed on their ability to use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
- Students will be assessed on their ability to evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics as well as possible social, cultural and environmental impacts.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- HHMI Video - Got Lactase? The Co-Evolution of Genes and Culture (http://www.hhmi.org/biointeractive/making-fittest-got-lactase-co-evolution-genes-and-culture)
- Interpreting Pedigrees and Asking Questions

In-Class Activities and Laboratory Experiences:

- Lactose Intolerance Pedigree Analysis
- Human Genetics (looking at traits within a family)
- Constructing Explanations from Fruit Fly Crosses
- Virtual Genetics Lab - Poster Argumentation Session
- Dragon Genetics
- Video: Secret of Photo 51
- DNA Structure Modeling
- DNA Replication Modeling
- Webquests:
    - DNA
    - Replication
    - Cell Division
    - Mitosis and Meiosis
    - Protein Synthesis
- Practice Transcribing and Translating Genes
- BRCA Screening with Simulated Gel Electrophoresis
- SNP Analysis and Pharmacogenetics
- Play Doh Cell Size Modeling Lab
- Onion Root Mitosis Lab
- Crossing Over Simulation
- Modeling mitosis and meiosis
- Video: Cracking the Genetic Code
- Karyotype Analysis
- POGIL Activities
    - DNA Structure and Replication
    - Cell Size
    - The Cell Cycle
    - Mitosis
    - Meiosis
- Gizmos:
    - Temperature and Sex Determinati
    - Protein Synthesis STEM Case
    - Cell Division
    - Meiosis
    - Meowsis STEM Case

Closure and Reflection Activities:

- Sickle cell genetics with HHMI video and review activity:
  - The Making of the Fittest: Natural Selection in Humans (http://www.hhmi.org/biointeractive/making-fittest-natural-selection-humans)
- Tom Ato's New Crop
- GMO Labeling Debate (CRP5)
- Mitosis Puzzle
- Case Study: Baby Doe vs. the Prenatal Clinic (Meiosis Review) -- (CRP5)

Instructional Materials:

- Canvas
- Calculators
- Computers with internet access, word processor and a spreadsheet
- Projector for teacher's computer or a Smartboard
- POGIL Biology
- Microscope

Technology Connections:

- Gizmos (http://gizmos.explorelearning.com)
- Next Generation Science Storylines (https://www.nextgenstorylines.org/)
- Virtual Fly Lab (http://www.sciencecourseware.org/vcise/drosophila/)
- HHMI Videos:
  - The Double Helix (http://www.hhmi.org/biointeractive/double-helix)
  - The Making of the Fittest: The Birth and Death of Genes (http://www.hhmi.org/biointeractive/making-fittest-birth-and-death-genes)
- Documentary Films:
  - Harvest of Fear (GMOs)
  - The Emperor of all Maladies (http://www.pbs.org/show/story-cancer-emperor-all-maladies/)
- Gel Electrophoresis Virtual Lab (http://learn.genetics.utah.edu/content/labs/gel/)
- Control of Cell Cycle Game (https://www.nobelprize.org/educational/medicine/2001/)
- DNA Code (http://www.dnai.org/a/index.html)
- Mitosis (http://www.biology.arizona.edu/cell_bio/tutorials/cell_cycle/main.html)
- Cancer (http://www.biology.iupui.edu/biocourses/N100/2k4ch8mitosisnotes.html)
- Mitosis Animation (http://www.stolaf.edu/people/giannini/flashanimat/celldivision/crome3.swf)
- Meiosis Tutorial (http://www.biology.arizona.edu/cell_bio/tutorials/meiosis/main.html)
- Meiosis Animation (http://www.stolaf.edu/people/giannini/flashanimat/celldivision/meiosis.swf)

- How Cells Divide (http://www.pbs.org/wgbh/nova/body/how-cells-divide.html)
- Genomes and Chromosomes (http://ghr.nih.gov/handbook/hgp/genome)
- Karyotype (http://learn.genetics.utah.edu/content/begin/traits/karyotype/)
- DNA Replication (http://nobelprize.org/educational_games/medicine/dna_double_helix/)
- Copying the Code (http://www.dnai.org/a/index.html)
- DNA Replication/Replication Factory (http://www.wiley.com/college/pratt/0471393878/student/animations/dna_replication/index.html)
- DNA Replication (http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/dna-
- rna2.swf)
- Mutations (http://evolution.berkeley.edu/evolibrary/article/mutations_03)
- Protein Synthesis (http://www.pbs.org/wgbh/aso/tryit/dna/)
- Transcribe and Translate a Gene (http://learn.genetics.utah.edu/content/molecules/transcribe/)
- Protein Synthesis (http://www.wisc-online.com/objects/index_tj.asp?objid=AP1302)
- Protein Synthesis (http://www.learnerstv.com/animation/biology/Proteinsynthesis.swf)

Unit 5: Ecology (3-4 Weeks)

Why Is This Unit Important?

All biological systems are composed of parts that interact with each other. These interactions result in characteristics not found in the individual parts alone. In other words, 'the whole is greater than the sum of its parts.' All biological systems from the molecular level to the ecosystem level exhibit properties of biocomplexity and diversity. Together, these two properties provide robustness to biological systems, enabling greater resiliency and flexibility to tolerate and respond to changes in the environment. Biological systems with greater complexity and diversity often exhibit an increased capacity to respond to changes in the environment.

A population is often measured in terms of genomic diversity and its ability to respond to change. Species with genetic variation and the resultant phenotypes can respond and adapt to changing environmental conditions. At the population level, as environmental conditions change, community structure changes both physically and biologically. The study of ecosystems seeks to understand the manner in which species are distributed in nature and how they are influenced by their abiotic and biotic interactions, e.g., species interactions. Interactions between living organisms and their environments result in the movement of matter and energy.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-LS2-1:** Use mathematical and/or computational representations to support explanation 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-LS4-6:** Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

- **HS-ETS1-4:** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Disciplinary Core Ideas:

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.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.C: 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. (HS-LS4-6)

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),(HS-LS4-6.)*

Science and Engineering Practices:

Using Mathematics and Computational Thinking

- Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (HS-LS2-1)
- Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2)
- Create or revise a simulation of a phenomenon, designed device, process, or system. (HS-LS4-6)

Constructing Explanations and Designing Solutions

- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-LS2-7)

Engaging in Argument from Evidence

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS2-6)
- Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. (HS-LS2-8)

Cross Cutting Concepts:

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS2-8),(HS-LS4-6)

Scale, Proportion, and Quantity

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1)
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6),(HS-LS2-7)

Enduring Understandings:

- 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).
- 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).

- 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)
- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (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 (HS-LS2-7)
- The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis (HS-LS2-5).

Essential Questions:

- How do organisms interact with each other and their environment?
- What are the effects of organismal interaction?
- What factors limit population size?
- What happens when new ecosystems are created or when existing communities undergo massive changes such as forest fire?
- How are humans affecting the environment and what can we do about it?

Acquired Knowledge:

- Identify biotic and abiotic factors affecting population growth.
- Contrast exponential and logistic population growth.
- Provide examples of adaptations that have evolved in prey populations due to selective pressures over long periods of time.
- Describe factors that affect biodiversity.
- Describe the differences between primary and secondary succession.
- Describe the relationships between species and the physical environment in a given ecosystem.
- Predict the impact of an extreme disturbance on resources and habitat availability
- Explain why biodiversity is important to ecosystems and humans.
- Connect population distribution patterns to survival and reproductive mechanisms.
- Explain how group behavior influences survival and reproductive success.
- Identify possible negative consequences of solutions that would outweigh their benefits.

Acquired Skills:

- Create a model to illustrate how interactions among living systems and with their environment result in the movement of matter and energy.
- Describe the transfer of matter and energy between trophic levels.
- Explain why lower trophic levels have greater biomass/population sizes/energy than higher trophic levels.
- Analyze data to provide evidence that the growth of populations are limited by access to resources and selective pressures.
- Analyze data on population density, population distribution and species variety to support a claim about factors affecting biodiversity.
- Analyze data to identify the impact of a keystone species on an ecosystem.
- Analyze data illustrating the effect of a disturbance on an ecosystem.
- Make scientific claims and predictions about how specific human activities that impact species diversity within an ecosystem ultimately influence ecosystem stability.

Assessments:

Formative Assessments:

- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Population Growth Modeling Lab: Students analyze (i.e., graph) population size data to compare and contrast exponential growth and logistic growth.
- Human Threats to Biodiversity Modeling Project: -Students design and evaluate a potential solution to mitigate the effects of a human threat to biodiversity. Students then use or create a computer simulation that tests that ability of that solution to minimize the effects of human activity (e.g., overpopulation, habitat destruction, invasive species, pollution, global warming) on a threatened/endangered species or to genetic variation within a species.

Benchmarks:

- Students will be assessed on their ability to use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
- Students will be assessed on their ability to evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.
- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- Students will be assessed on their ability to design, evaluate and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- Students will be assessed on their ability to create or revise a simulation to test a solution to mitigate adverse impacts of human activity
- Students will be assessed on their ability to analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- Students will be assessed on their ability to use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Video: Trials of Life: Friends and Rivals
- Video: Trials of Life: Hunting and Escaping
- Chasing Coral documentary

In-Class Activities and Laboratory Experiences:

- Natural Controls of Populations Lab
- Study of Population Density on a Suburban Lawn Lab
- Parking Lot Biodiversity Lab
- Ecological Succession in a Forest Lab
- Ups and Downs of Frogs Lab
- POGIL Activities:
    - Energy Transfer among Organisms
    - Nutrient Cycles
    - Ecological Relationships
    - Succession
    - Population Distribution
    - Population Growth
- Gizmos:
    - Ecosystems STEM Case
    - Coral Reefs 1 (Abiotic Factors)
    - Coral Reefs 2 (Biotic Factors)

Instructional Materials:

- Canvas
- Calculators
- Computers with internet access, word processor and a spreadsheet
- Projector for teacher's computer or a Smartboard
- POGIL Biology

Technology Connections:

- Gizmos (http://gizmos.explorelearning.com)
- Next Generation Science Storylines (https://www.nextgenstorylines.org/)
- Population Growth Modeling (https://www.learner.org/courses/envsci/interactives/ecology/ecology.html)
- Biodiversity Hotspots (http://www.conservation.org/How/Pages/Hotspots.aspx)
- Food Web Simulation (https://www.learner.org/courses/envsci/interactives/ecology/ecology.html)

Sample Standards Integration

<u>**Career Readiness, Life Literacies, and Key Skills**</u> **9.4.12.CI.1:** For example, in Unit 3, students utilize their understanding of traits and variations with the Dragon Genetics activity **9.4.12.CT.2:** For example, in Unit 5, students will work collaboratively to build a project where they apply their understanding of socioeconomic impacts in the Natural Controls of Populations Lab . **9.4.8.IML.5:** For example, in Unit 3, students utilize research in the Virtual Genetics Lab – Poster argumentation Session activity
<u>**8.1 Computer Science and Design Thinking**</u> **All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and create and communicate knowledge.** • For example in Unit 1, students will access, manage, evaluate, and synthesize information to plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. • For example in Unit 3, students develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment when they evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics as well as possible social, cultural and environmental impacts.
LGBT and Disabilities Law: In Unit 3 the Gender Expression Project has students explore the process and limits of genetics on gender expression

Career Exploration:

- In Unit 3 there is a Career Exploration: Genetic Counselor

Interdisciplinary Connections

NJSLS.RST.9-10.8. Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

NJSLS.RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

NJSLS.RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

NJSLS.RST.11-12.8 Evaluate the hypotheses, data, analysis and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

NJSLS.SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning and well-chosen details; use appropriate eye contact, adequate volume and clear pronunciation.

NJSLS.SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual and interactive elements) in presentations to enhance understanding of findings, reasoning and evidence and to add interest.

NJSLS.WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

NJSLS.WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

NJSLS.WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection and research.

NJSLS.WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

These standards are met through the completion of the benchmark performances in all 5 units. For example in:

- Unit 1: Students will be assessed on their ability to plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
- Unit 2: Students will be assessed on their ability to communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
- Unit 3: Students will be assessed on their ability to 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.
- Unit 4: Students will be assessed on their ability to construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
- Unit 5: Students will be assessed on their ability to 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.

NJSLS.MP.2 Reason abstractly and quantitatively.

NJSLS.MP.4 Model with mathematics.

NJSLS.HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

NJSLS.HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

NJSLS.HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

NJSLS.HSS-IC.A.1Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

NJSLS.HSS-ID.A.1Represent data with plots on the real number line.

These standards are met through the completion of the benchmark performances in all 5 units. For example in:

- Unit 1: Students will be assessed on their ability to plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
- Unit 2: Students will be assessed on their ability to apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
- Unit 3: Students will be assessed on their ability to use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
- Unit 4: Students will be assessed on their ability to use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
- Unit 5: Students will be assessed on their ability to use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.