BIOLOGY
GRADE9-12

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: Evolution**, students construct explanations and design solutions, analyze and interpret data and engage in argument from evidence 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 understandings of 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 3: Heredity and Reproduction**, students analyze data 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 4: Matter and Energy Transformations**, students construct explanations for the role of energy in the cycling of matter in organisms and ecosystems. 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 5: Interdependence**, 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.

21st Century Life and Careers

In today's global economy, students need to be lifelong learners who have the knowledge and skills to adapt to an evolving workplace and world. To address these demands, Standard 9, 21st Century Life and Careers, which includes the 12 Career Ready Practices, establishes clear guidelines for what students need to know and be able to do in order to be successful in their future careers and to achieve financial independence.

The 12 Career Ready Practices

These practices outline the skills that all individuals need to have to truly be adaptable, reflective, and proactive in life and careers. These are researched practices that are essential to career readiness.

- CRP2. Apply appropriate academic and technical skills
- CRP4. Communicate clearly and effectively and with reason.
- CRP5. Consider the environmental, social and economic impacts of decisions.
- CRP6. Demonstrate creativity and innovation.
- CRP7. Employ valid and reliable research strategies.
- CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

9.3 Career and Technical Education

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.SM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

Technology Integration

8.1 Educational Technology

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.

- 8.1.12.A.4. Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the result.
- 8.1.12.A.5. Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results
- 8.1.12.B.2. Apply previous content knowledge by creating and piloting a digital learning game or tutorial.
- 8.1.2.B.3. Analyze ethical and unethical practices around intellectual property rights as influenced by human wants and/or needs.
- 8.1.12.E.1. Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.
- 8.1.12.F.1. Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and/or social needs.

8.2 Technology Education, Engineering, Design and Computational Thinking - Programming

All students will 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.

- 8.2.12.A.1. Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation.
- 8.2.12.A.2. Analyze a current technology and the resources used to identify the trade-offs in terms of availability, cost, desirability, and waste.

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.

Enduring Understandings:

- 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.
- Cellular function is maintained through the regulation of cellular processes in response to internal and external environmental conditions.

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
- Plan and conduct investigations
- Analyzing data and graphing
- Constructing scientific explanations using experimental evidence
- Generating scientific arguments about the definition of living things

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

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
- Food Chains and Energy in Ecosystems Lab (energy pyramids)
- Food Chain simulation
- POGIL Activities:
    - Scientific Inquiry
    - Experimental Variables
    - Analyzing and Interpreting Scientific Data
    - Prokaryote and Eukaryote Cells
    - Organelles in Eukaryote Cells

Closure and Reflection Activities:

- Student Discussion
- Journal Response (Arguing from Evidence)

Instructional Materials:

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

Technology Connections:

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

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

- HS-LS1-3

Unit 2: Evolution (3 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.

Enduring Understandings:

- New traits may result from new combinations of existing genes or from mutations of genes in reproductive cells within a population.
- Molecular evidence (e.g., DNA, protein structures, etc.) substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched.
- The principles of evolution (including natural selection and common descent) provide a scientific explanation for the history of life on Earth as evidenced in the fossil record and in the similarities that exist within the diversity of existing organisms.
- Evolution occurs as a result of a combination of the following factors:
    - Ability of a species to reproduce
    - Genetic variability of offspring due to mutation and recombination of genes
    - Finite supply of the resources required for life
    - Natural selection, due to environmental pressure, of those organisms better able to survive and leave offspring

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 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 the 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

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

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:

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

Technology Connections:

- 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 Labs:
  - Recent Adaptations in Humans (http://www.hhmi.org/biointeractive/recent-adaptations-humans)
  - Human Evolution Timeline Interactive (http://humanorigins.si.edu/evidence/human-evolution-timeline-interactive)
  - Peppered Moth Simulation (http://peppermoths.weebly.com/)

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

- HS-LS3-3
- HS-LS4-2
- HS-LS4-3
- HS-LS4-4
- HS-LS4-1
- HS-LS4-5

Unit 3: 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 cytoplasm 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.

Enduring Understandings:

- Cells divide through the process of mitosis, resulting in daughter cells that have the same genetic composition as the original cell to be used for growth, repair and replace.
- The instructions for forming species characteristics are carried in DNA which are determined by a sequence of amino acids, which result in specific proteins.
- All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways.
- Sorting and recombination of genes in sexual reproduction result in a great variety of possible gene combinations in the offspring of any two parents.
- Inserting, deleting, or substituting DNA segments can alter the genetic code. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.

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.
- Describe evidence that supports the claim that DNA contains genetic information (e.g., Avery, Hershey-Chase)
- 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 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 relationship between DNA, proteins and the traits of an organism.
- Create a drawing or model to show how mitosis produces two genetically identical daughter cells from one parent cell.
- Create a drawing or model to show 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
- POGIL - Cell Size

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

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:

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

Technology Connections:

- 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)

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

- HS-LS3-2
- HS-LS1-1
- HS-LS3-1
- HS-LS1-4
- HS-ETS1-3

Unit 4: Matter and Energy Transformations (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.

Membranes allow cells to create and maintain internal environments that differ from external environments. The structure of cell membranes results in selective permeability; the movement of molecules across them via osmosis, diffusion and active transport maintains dynamic homeostasis. In eukaryotes, internal membranes partition the cell into specialized regions that allow cell processes to operate with optimal efficiency. Each compartment or membrane-bound organelle enables localization of chemical reactions.

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.

Enduring Understandings:

- Energy flows one way through ecosystems, but matter is recycled.
- The movement of matter and energy through ecosystems results in chemical elements being recombined into different products. 3. Each recombination of matter and energy results in storage and dissipation of energy into the environment as heat. 4. Continual input of energy from sunlight keeps matter and energy flowing through ecosystems. 5. Plants have the capability to take energy from light to form sugar molecules containing carbon, hydrogen and oxygen.
- In both plant and animal cells, sugar is a source of energy and can be used to make other carbon-containing (organic) molecules.
- All organisms must break the high-energy chemical bonds in food molecules during cellular respiration to obtain the energy needed for life processes.

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 larger 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
- Describe the transfer of matter and energy between trophic levels.
- Explain why lower trophic levels have greater biomass/population sizes/energy than higher tropic levels.
- Account for inefficiencies in the transfer of matter and energy.

Acquired Skills:

- Construct models that explain the movement of molecules across membranes with membrane structure and function (e.g., osmosis, diffusion).
- 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 rubrics

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

Closure and Reflection Activities:

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

Instructional Materials:

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

Technology Connections:

- 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)

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

- HS-LS1-6
- HS-LS1-7
- HS-LS2-3
- HS-LS1-5
- HS-LS1-2
- HS-LS2-4
- HS-LS2-5
- HS-ETS1-2

Unit 5: Interdependence (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.

Enduring Understandings:

- Energy flows one way through an ecosystem from the sun through the trophic levels (from producers to consumers).
- Some species can be more important than others to the overall health of an ecosystem, particularly if they are removed completely or relocated to non-native environments.
- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).
- Changes in the environment that are caused by human activity can disrupt an ecosystem and threaten the survival of some species.

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.
- 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.
- Project: Human Threats to Biodiversity Modeling - 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

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

Instructional Materials:

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

Technology Connections:

- 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)

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

- HS-LS2-1
- HS-LS2-8
- HS-LS2-6
- HS-LS2-2
- HS-LS2-7
- HS-LS4-6
- HS-ETS1-1
- HS-ETS1-4

Sample Standards Integration

<u>21st Century Skills & Career Readiness Practices</u>

CRP2. Apply appropriate academic and technical skills

An example of the application of this standard is found in unit 1 with the Practice Graphing Data activity

CRP4. Communicate clearly and effectively and with reason.

An example of the application of this standard is found in unit 3 with the Virtual Genetics Lab - Poster Argumentation Session activity

CRP5. Consider the environmental, social and economic impacts of decisions.

An example of the application of this standard is found in unit 5 with the Natural Controls of Populations Lab

CRP6. Demonstrate creativity and innovation.

An example of the application of this standard is found in unit 3 with the Dragon Genetics acitivty

CRP7. Employ valid and reliable research strategies.

An example of the application of this standard is found in unit 1 with the Should Viruses Be Classified as Living Things?

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

An example of the application of this standard is found in unit 2 with the Biochemical Evidence and Cladograms activity

<u>9.3 Career and Technical Education</u>

9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.

An example of the application of this standard is found in unit 1 with the Effect of Water Temperature on Goldfish Respiration Rate Lab

9.3.ST.SM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

An example of the application of this standard is found in unit 2 with the Lizard Island Biogeography Lab.

8.1 Educational Technology
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.

- **8.1.12.A.4. Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the result.**
- **8.1.12.A.5. Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results**
- **8.1.12.B.2. Apply previous content knowledge by creating and piloting a digital learning game or tutorial.**
- **8.1.2.B.3. Analyze ethical and unethical practices around intellectual property rights as influenced by human wants and/or needs.**
- **8.1.12.E.1. Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.**
- **8.1.12.F.1. Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and/or social needs.**

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.

8.2 Technology Education, Engineering, Design and Computational Thinking - Programming
All students will 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.

- **8.2.12.A.1. Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation.**
- **8.2.12.A.2. Analyze a current technology and the resources used to identify the trade-offs in terms of availability, cost, desirability, and waste.**

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.

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.