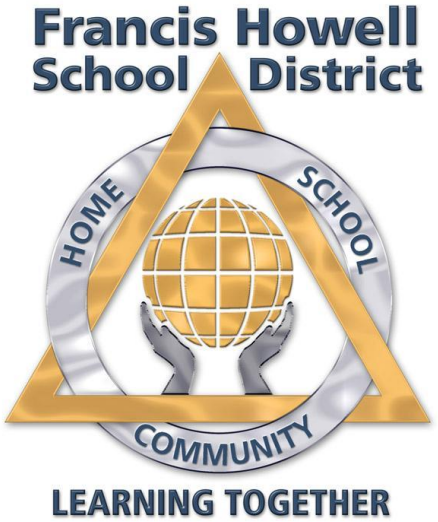
Biology

Curriculum



Board Approved: May 2018

Francis Howell School District

Mission Statement

The mission of the Francis Howell School District is to prepare students today for success tomorrow.

Vision Statement

Every student will graduate with college and career readiness skills.

Values

Francis Howell School District is committed to:

- Providing a consistent and comprehensive education that fosters high levels of academic achievement
- Operating safe and well-maintained facilities
- Providing a safe learning environment for all students
- Promoting parent, community, student, and business involvement in support of the school district
- Ensuring fiscal responsibility
- Developing responsible citizens
- Operating as a professional learning community
- Making appropriate use of technology

Francis Howell School District Graduate Goals

Upon completion of their academic study in the Francis Howell School District, students will be able to:

1. Gather, analyze and apply information and ideas.
2. Communicate effectively within and beyond the classroom.
3. Recognize and solve problems.
4. Make decisions and act as responsible members of society.

Science Graduate Goals

The students in the Francis Howell School District will graduate with the knowledge, skills, and attitudes essential to leading a productive, meaningful life. Graduates will:

- Understand and apply principles of scientific investigation.
- Utilize the key concepts and principles of life, earth, and physical science to solve problems.
- Recognize that science is an ongoing human endeavor that helps us understand our world.
- Realize that science, mathematics, and technology are interdependent, each with strengths and limitations that impact the environment and society.
- Use scientific knowledge and scientific ways of thinking for individual and social purposes.

Biology Course Rationale

Science education develops science literacy. Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning. Scientific literacy has become a necessity for everyone.

To accomplish this literacy, science courses will reflect the following:

- Develop scientific reasoning and critical thinking skills.
- Extend problem-solving skills using scientific methods.
- Include lab-based experiences.
- Strengthen positive attitudes about science.
- Incorporate the use of new technologies
- Provide relevant connections to personal and societal issues and events.

Biology Course Description

In this course the student will engage in scientific inquiry, explore biochemistry, the cell, bioenergy, mechanisms of genetics, biotechnology and how humans impact the planet. Students will also study change in organisms over time, classification, and ecosystems. Lab experiences are an integral part of the course.

Biology Curriculum Team

Curriculum Committee

Samuel Berendzen	Francis Howell High School
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Janet Eubanks	Francis Howell High School
LuAnne Scott	Francis Howell Central High School
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Science Content Leader	Amy Ridling
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Chief Academic Officer	Nicole Whitesell
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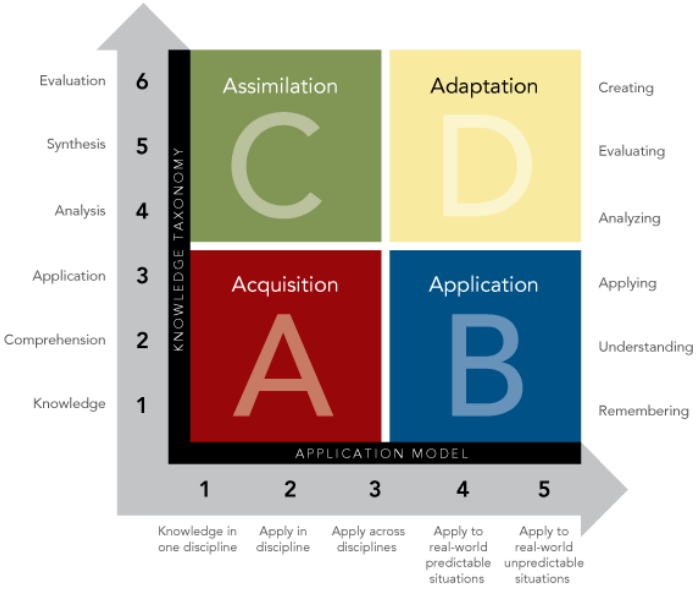
Curriculum Notes

All FHSD performance tasks and sample learning activities are aligned not only to understandings and standards, but also the Rigor and Relevance Framework and 21st Century Skills. Information on these two things is provided below or by clicking on the hyperlinks.

Rigor and Relevance Framework

The Rigor/Relevance Framework is a tool developed by the International Center to examine curriculum, instruction, and assessment along the two dimensions of higher standards and student achievement.



The Rigor/Relevance Framework has four quadrants.
Quadrant A represents simple recall and basic understanding of knowledge for its own sake. Examples of Quadrant A knowledge are knowing that the world is round and that Shakespeare wrote Hamlet.

Quadrant C represents more complex thinking but still knowledge for its own sake. Quadrant C embraces higher levels of knowledge, such as knowing how the U.S. political system works and analyzing the benefits and challenges of the cultural diversity of this nation versus other nations.

Quadrants B and D represent action or high degrees of application. Quadrant B would include knowing how to use math skills to make purchases and count change. The ability to access information in wide-area network systems and the ability to gather knowledge from a variety of sources to solve a complex problem in the workplace are types of Quadrant D knowledge.

A	B	C	D
Students gather and store bits of knowledge and information. Students are primarily expected to remember or understand this knowledge.	Students use acquired knowledge to solve problems, design solutions, and complete work. The highest level of application is to apply knowledge to new and unpredictable situations.	Students extend and refine their acquired knowledge to be able to use that knowledge automatically and routinely to analyze and solve problems and create solutions.	Students have the competence to think in complex ways.

21st Century Skills

These skills have been pared down from 18 skills to what are now called the 4Cs. The components include critical thinking, communication, collaboration, and creativity. Critical thinking is focused, careful analysis of something to better understand and includes skills such as arguing, classifying, comparing, and problem solving. Communication is the process of transferring a thought from one mind to others and receiving thoughts back and includes skills such as choosing a medium (and/or technology tool), speaking, listening, reading, writing, evaluating messages. Collaboration is working together with others to achieve a common goal and includes skills such as delegating, goal setting, resolving conflicts, team building, decision-making, and managing time. Creativity is expansive, open-ended invention and discovery of possibilities and includes skills such as brainstorming, creating, designing, imagining, improvising, and problem-solving.

Standards

Standards aligned to this course can be found:

Science Standards

Next Generation Science Standards High School LIfe Science

Missouri Science Standards 6-12

National Educational Technology Standards

http://www.iste.org/STANDARDS

Units & Standards Overview

Semester 1 **Semester 2**

Unit 1:Structure, Function, And Homeostasis	**Unit 2: Variation and Inheritance**
Anchoring Phenomena: The Flu Preparing for the next pandemic; what have we learned over the last 100 years?	**Anchoring Phenomena**: Cystic Fibrosis and ways to "help" using CRISPR technology
Standards Addressed **HS-LS1-1** HS-LS1-2 **HS-LS1-3** HS-LS1-4 HS-LS1-6	**Standards Addressed** MS-LS3-1 **MS-LS3-2** HS-LS3-1 **HS-LS3-2** HS-LS3-3
PE Assessment:*Unit 1 Biology PE* *Unit 1 Pre-AP Performance Event*	**PE Assessment:** PE Unit 2 Heredity and Variation

Unit 3: Evolution	**Unit 4: Carbon and Life**	**Unit 5: Sustainability**	**Unit 6: Human Impact**
Anchoring Phenomena: Transition: Dinosaurs to Birds	**Anchoring Phenomena:** Carbon Dioxide	**Anchoring Phenomena:** Food	**Anchoring Phenomena:**
Standards Addressed **HS-LS4-1** HS-LS4-2 HS-LS4-3 HS-LS4-4 HS-LS4-5 MS-LS4-3	**Standards Addressed** **HS-LS1-5** **HS-LS1-7** HS-LS2-5 (not assessed at this level but it is at sustainability unit)	**Standards Addressed** **HS-LS2-1** **HS-LS2-4** **HS-LS2-5**	**Standards Addressed** HS-LS2-6 **HS-LS2-7** HS-LS4-6 HS-ESS3-4 HS-ESS2-7
PE Assessment: Unit 3 PE: Evolution - What Would T. Rex Taste Like	PE Assessment: Unit 4 PE: Super Slugalicious	PE Assessment: Unit 5 Sustainability Unit Performance Event	PE Assessment:

Course Map

	Unit Description	PE Summary	PE Standards
Unit 1: Structure, Function and Homeostasis **10 weeks**	In this unit students will investigate the structure and function of macromolecules, DNA, proteins and somatic cell division. Through the use of creating models and developing evidence statements, students will be able to explain how the structure and function of these topics allows an organism to maintain homeostasis.	*Unit 1 Biology PE* *Unit 1 Pre-AP Performance Event* This assessment has students transcribe and translate a sequence of DNA. Students will locate errors in three other DNA sequences. Students will then describe how homeostasis is disrupted when a protein is not coded for properly.	**HS-LS1-1** **HS- LS1-3**
Unit 2: Variation and Inheritance **6 weeks**	In this unit students will investigate how DNA and chromosomes store our genetic information. They will also create models to understand how traits are passed from one generation to the next in sexually reproducing organisms, and then use these models to show how variation is achieved during gamete formation, and make predictions as to the genetic makeup of future generations.	Heredity and Variation Students will analyze different methods of inheriting the gene for lactose intolerance. The students will have to create a model of meiosis to explain how variation can be achieved in the offspring, and analyze other sources of variation such as mutation, and environmental causes.	*MS-LS3-1* ***MS-LS3-2*** ***HS-LS3-1*** ***HS-LS3-2*** ***HS-LS3-3***
Unit 3: Evolution **5 weeks**	Students will evaluate scientific evidences to be able to describe how populations change over time. They will make, use and analyze models to support the idea that common ancestry and biological evolution are supported by multiple lines of evidence. Examples of the evidence include but are not limited to genetic inheritance, the fossil record, cladograms, and environmental changes. They will also construct explanations based on evidence that natural selection leads to adaptations of	Evolution - What Would T. Rex Taste Like Students will analyze different lines of evidence to determine relatedness between a T. rex dinosaur and other organisms. They will build a chart making comparisons and identify on a cladogram where certain traits would appear. They will then use their analysis to determine which organism the T. rex is most closely related to and make a prediction as to what T. rex would taste like.	**HS - LS4-1**

	populations and that the process of evolution primarily results from four factors: (1) the potential of 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.		
Unit 4: Carbon and Life **4 weeks**	Students will model the transfer of energy through the processes of photosynthesis and cellular respiration. Students will illustrate how photosynthesis transforms light energy into stored chemical energy. Students will understand the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.	Unit 4 PE: Super Slugalicious Students will create a model that depicts the relationship between photosynthesis and respiration.	**HS-LS1-5** **HS-LS1-7**
Unit 5: Sustainability **4 weeks**	Students will understand how organisms interact with each other and the impact humans can have on these interactions. They will also understand how energy and matter flow within and through the biosphere. Students will also understand the role that biodiversity plays in the sustainability of an ecosystem.	Sustainability Unit Performance Event Students interpret a food chain for energy flow and matter cycling. Then they apply the concepts of Systems and System Models when they create their own food chain model. Demonstrating their understanding of Scale, Proportion, and Quantity they perform a CER to evaluate changes in energy and biomass in their model. Students will then use Mathematics and Computational Thinking to determine the viability of a change in the number of predators.	**HS-LS2-1** **HS-LS2-4** **HS-LS2-5**
Unit 6 : Human Impacts	The Human Impact Unit is intended to be an opportunity for students to show what they have	Students will use the process of engineering design to identify a problem related to	HS-LS2-6 **HS-LS2-7**

3 weeks	learned throughout the year by applying their knowledge to solve a problem. Students will also design a plan to monitor the effectiveness of the proposed solution.	threatened or endangered species, or to genetic variation of organisms for multiple species and design a solution that would minimize human impacts on this problem.	HS-LS4-6 HS-ESS3-4 HS-ESS2-7

Unit 1: **Structure, Function and Homeostasis**

Content Area: Science	**Course: Biology**	**UNIT: Structure, Function and Homeostasis**

Unit Description: In this unit students will investigate the structure and function of macromolecules, DNA, proteins and somatic cell division. Through the use of creating models and developing evidence statements, students will be able to explain how the structure and function of these topics allows an organism to maintain homeostasis.	**Unit Timeline:** 10 weeks

DESIRED Results

Transfer Goal (Science and Engineering Practices) - ***Students will be able to independently use their learning to……***

1. Ask questions and define problems.
2. Develop and use models.
3. Plan and carry out investigations
4. Analyze and interpret data.
5. Use mathematical and computational thinking.
6. Construct explanations and design solutions.
7. Engage in an argument from evidence.
8. Obtain, evaluate, and communicate information.

Understandings (Cross Cutting Concepts) – *Students will understand… (Big Ideas)*

1. Patterns
2. Cause and Effect
3. Scale, Proportion, & Quantity
4. Systems & System Models
5. Energy and Matter
6. Structure and Function
7. Stability and Change

Essential Questions: ***Students will keep considering…***

- How does DNA control growth and function of cells?
- How is structure related to function at all biological levels of organization?
- How do cells grow and reproduce?
- How does life result from chemical structure and function?
- How do organisms maintain a biological balance between their internal and external environments?

Phenomena used to anchor this unit: Smithsonian Pandemic Flu article

Standards Addressed
Students who demonstrate understanding can: **HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.] (Link to MLS 9-12-LS1.A.1)** HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.] (Link to MLS 9-12-LS1.A.2) **HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.] (Link to MLS 9-12-LS1.A.3)** HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. [Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.] (Link to MLS 9-12-LS1.B.4) HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.] (Link to MLS 9-12-LS1.C.8)

Disciplinary Core Ideas **Students will know...**	**Cross Cutting Concepts** **Students will understand….**	**Science and Engineering Practice** **Students will be able to...**
LS1.A: Structure and Function Systems of specialized cells within organisms help them perform the essential	Structure and Function ● regions of DNA called genes determine the structure of proteins, which carry out the essential functions	Students construct an explanation that includes the idea that regions of DNA called genes determine the structure of proteins, which carry out the essential functions of life through systems of specialized cells.

functions of life. All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.) .	of life through systems of specialized cells. ● All cells contain DNA ● DNA contains regions that are called genes; ● The sequence of genes contains instructions that code for proteins; ● Groups of specialized cells (tissues) use proteins to carry out functions that are essential to the organism	Students use reasoning to connect evidence, along with 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, to construct the explanation. Students describe the following chain of reasoning in their explanation: 1. Because all cells contain DNA, all cells contain genes that can code for the formation of proteins 2. Body tissues are systems of specialized cells with similar structures and functions, each of whose functions are mainly carried out by the proteins they produce. 3. Proper function of many proteins is necessary for the proper functioning of the cells. 4. Gene sequence affects protein function, which in turn affects the function of body tissues.
LS1.A: Structure and Function 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.	Systems and System Models Students understand how the interaction between systems provides specific functions in multicellular organisms. Students make a distinction between the accuracy of the model and actual body systems and functions it represents.	Students develop a model in which they identify and describe the relevant parts (e.g., organ system, organs, and their component tissues) and processes (e.g., transport of fluids, motion) of body systems in multicellular organisms. In the model, students describe the relationships between components, including: 1. The functions of at least two major body systems in terms of contributions to overall function of an organism; 2. Ways the functions of two different systems affect one another 3. A system's function and how that relates both to the system's parts and to the overall function of the organism. Students use the model to illustrate how the interaction between systems provides specific functions in multicellular organisms. Students make a distinction between the accuracy of the model and actual body systems and functions it represents.

LS1.A Structure and Function 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.	Stability and change Feedback (negative or positive) can stabilize or destabilize a system.	Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including: 1. Changes within a chosen range in the external environment of a living system 2. Responses of a living system that would stabilize and maintain the system's internal conditions (homeostasis), even though external conditions change, thus establishing the positive or negative feedback mechanism Students describe why the data will provide information relevant to the purpose of the investigation Students will plan an investigation. In the investigation plan, students describe: 1. How the change in the external environment is to be measured or identified 2. How the response of the living system will be measured or identified 3. How the stabilization or destabilization of the system's internal conditions will be measured or determined 4. The experimental procedure, the minimum number of different systems (and the factors that affect them) that would allow generalization of results, the evidence derived from the data, and identification of limitations on the precision of data to include types and amounts 5. Whether the investigation will be conducted individually or collaboratively Students will collect and record changes in the external environment and organism responses as a function of time. Students evaluate their investigation including: 1. assessment of the accuracy and precision of the data, as well as limitations (e.g., cost, risk, time) of the investigation and make suggestions for refinement. 2. Assessment of the ability of the data to provide the

		evidence required. If necessary, students refine the investigation plan to produce more generalized data.
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.	Systems and System Models From the given model, students understand the components of the model relevant for illustrating the role of mitosis and differentiation in producing and maintaining complex organisms. Students understand the components of the given model.	From the given model, students identify and describe the components of the model relevant for illustrating the role of mitosis and differentiation in producing and maintaining complex organisms, including: ● Genetic material containing two variants of each chromosome pair, one from each parent ● Parent and daughter cells (i.e., inputs and outputs of mitosis) ● A multi-cellular organism as a collection of differentiated cells. Students identify and describe the relationships between components of the given model, including: ● Daughter cells receive identical genetic information from a parent cell or a fertilized egg. ● Mitotic cell division produces two genetically identical daughter cells from one parent cell. ● Differences between different cell types within a multicellular organism are due to gene expression — not different genetic material within that organism. Students use the given model to illustrate that mitotic cell division results in more cells that: ● Allow growth of the organism ● Can then differentiate to create different cell types ● Can replace dead cells to maintain a complex organism. Students make a distinction between the accuracy of the model and the actual process of cellular division
LS1.C: Organization for Matter and Energy Flow in Organisms The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their	Energy and Matter Cellular respiration involves chemical reactions between sugar molecules and other molecules in which energy is released that can	Students construct an explanation that includes: ● The relationship between the carbon, hydrogen, and oxygen atoms from sugar molecules formed in or ingested by an organism and those same atoms found in amino acids and other large carbon-based

hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	be used to drive other chemical reactions. Chemical reactions involve changes in the energies of the molecules involved in the reaction. The matter flows in cellular processes are the result of the rearrangement of primarily the atoms in sugar molecules because those are the molecules whose reactions release the energy needed for cell processes.	molecules ● That larger carbon-based molecules and amino acids can be a result of chemical reactions between sugar molecules (or their component atoms) and other atoms. Students identify and describe the evidence to construct the explanation, including: ● All organisms take in matter (allowing growth and maintenance) and rearrange the atoms in chemical reactions ● Cellular respiration involves chemical reactions between sugar molecules and other molecules in which energy is released that can be used to drive other chemical reactions. ● Sugar molecules are composed of carbon, oxygen, and hydrogen atoms. ● Amino acids and other complex carbon-based molecules are composed largely of carbon, oxygen, and hydrogen atoms. ● Chemical reactions can create products that are more complex than the reactants. ● Chemical reactions involve changes in the energies of the molecules involved in the reaction. Students use a variety of valid and reliable sources for the evidence (e.g., theories, simulations, students' own investigations). Students use reasoning to connect the evidence, along with 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, to construct the explanation that atoms from sugar molecules may combine with other elements via chemical reactions to form other large carbon-based molecules. Students describe the following chain of reasoning for their explanation: ● The atoms in sugar molecules can provide most of the atoms that comprise amino acids and other complex carbon-based molecules.

		• The energy released in respiration can be used to drive chemical reactions between sugars and other substances, and the products of those reactions can include amino acids and other complex carbon-based molecules. • The matter flows in cellular processes are the result of the rearrangement of primarily the atoms in sugar molecules because those are the molecules whose reactions release the energy needed for cell processes. Given new evidence or context, students revise or expand their explanation about the relationships between atoms in sugar molecules and atoms in large carbon-based molecules, and justify their revision.
ISTE 5b	Students will collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.	
ISTE 5c	Students will break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.	
ISTE 3a	plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.	
ISTE 3b	evaluate the accuracy, perspective, credibility and relevance of information, media, data or other resources.	
ISTE 3c	curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.	

Unit 1: Assessment

EVIDENCE of LEARNING			
Understanding(s) Structure and Function Stability and change	Standards **HS-LS1-1** **HS- LS1-3**	**Unit Performance Assessment**: **Description of Performance Task:***Unit 1 Biology PE* *Unit 1 Pre-AP Performance Event* This assessment has students transcribe and translate a sequence of DNA. Students will locate errors in three other DNA sequences. Students will then describe how homeostasis is disrupted when a protein is not coded for properly. **The Crosscutting Concept** for **LS1-1** Structure and Function: **The SEP** for **LS1-1**:Constructing Explanations and Designing Solutions **The Crosscutting Concept** for **LS1-3**: Stability and Change Feedback (negative or positive) can stabilize or destabilize a system. **The SEP** for **LS1-3:** Planning and Carrying Out Investigations: **Teacher will assess:** *What criteria will be used in each assessment to evaluate attainment of the desired results?* ● A student who has mastered these concepts will be able to correctly identify errors in sequences of DNA and how they will impact amino acid sequence ● A student who has mastered these concepts will be able to explain how a change in DNA material affects the function of protein. **Performance:** **Mastery:***Students will show that they really understand when they…* 1. *Score an 80% on their Unit 1 performance event* **Scoring Guide:** Click here for scoring guide	**R/R Quadrant** **21 Century** B critical thinking communication

Unit 1: Sample Activities

SAMPLE LEARNING PLAN				
Understanding	**Standards**	**Major Learning Activities:**	**Instructional Strategy Category:**	**R/R Quadrant: 21C:**
Structure and Function Stability and change	HS-LS1-6 Planning and Carrying Out Investigations ITSE 5b,c	**1. Lesson**:Macromolecules and Nutrients: Students will explore different food samples and run different tests to determine the macromolecules that the food is made up of. Click here for link to Gizmo *This lesson requires computer access* **Objective**: 1) Students will be able to use data from lab simulations to identify four kinds of nutrients: simple sugars, starches, proteins and fats. 2)Students will be able to describe what nutrients are present in several common food, such as meat, juice, bread, and milk. **Learning activity:** Gizmo: Identifying Nutrients ● This activity could also be used as an inquiry activity leading into standard HS-LS1-6 OR... ● Up to this point, students will have been introduced to the 4 major classes of macromolecules (Carbohydrates, Lipids, Nucleic acids, and Proteins). This activity is to further explore the macromolecules and the role they play in nutrition through a simulation of testing food samples. **Check for understanding:** On the Gizmo activity there are assessment questions that the students can take in order to check for understanding after the lesson has been completed	Cues, Questions, and Advance organizers Summarizing and note taking Identifying Similarities and Differences Generating and Testing Hypotheses	C Critical Thinking
Structure and Function	HS-LS1-6 HS-LS1-2	**2. Lesson**: Macromolecules and Nutrients Food Label Activity *This lesson requires computer access but can be modified to be used with a*	Non-linguistic representations	A D

Stability and change	HS-LS1-3 Constructing explanations ISTE 3a, b, c	*text book.* Click here for the activity resource sheet **Objective**: 1) Students will be able to use resources to research background information on macromolecules. 2) Students will be able to look at food labels and identify the 4 major classes of macromolecules **Learning activity:** In this activity students will explore macromolecules down to their chemical composition through a webquest (although can be used with just a textbook as well) and then analyze food labels to determine what macromolecules they are composed off and then decide if that is a healthy food choice for an individual.	Identifying Similarities and Differences	Communication Critical Thinking
Systems and System Models	HS-LS1-2 Asking questions Developing and using models Planning and carrying out investigations Analyzing and interpreting data	**3. Lesson**: Enzymes (Inquiry Lab) https://www.biologycorner.com/2017/11/09/inquiry-investigation-enzyme-and-substrate-concentrations/ **Objective**: 1) Students will know how increasing the concentration of the substrate or enzyme affects reaction rate **Learning activity:** This activity is adapted from www.biologycorner.com Students will use this activity for an Enzyme Investigation Lab in order to explore the amount of enzyme on the effect of reaction rate. Students will collect evidence in order to develop a claim and put this on a CER sheet. **Check for understanding:** Students will be filling out a CER (claim evidence reasoning) Their claim should be supported by their evidence and their evidence should be supported by their reasoning	Cooperative learning Generating and Testing Hypotheses	D Creativity, Collaboration Communication, Critical Thinking
Structure and Function	HS-LS1-1 Asking questions Developing	**4. Lesson:** DNA Structure **Objective:** 1) Students will know the structure of DNA and by building models and explaining how the models represent the molecule of DNA (students should identify the strengths and weaknesses of each model; what does the model show, what doesn't the model show?)	Identifying Similarities and Differences Cooperative	A Collaboration Critical Thinking

	and using models	**Learning activity:** "Modern Genetics for All Students" Chapter 1 https://schoolpartnership.wustl.edu/instructional-materials/modern-genetics/ In the above link in chapter 1, it covers the structure of DNA. Students begin by building a 2 dimensional model of DNA out of nucleotide basis and analyzing it with their partners. They will simulate how replication occurs by separating their DNA molecules and joining with another group making complementary base pairs. They then will read an excerpt from The Cartoon Guide to Genetics and read "Spiral Staircase". The following day they build 3D models. Students compare the 2 different types of models and discuss the pros and cons of each type of model. **This is all in section C of the 1st chapter.** **Check for Understanding:** On student page 31, students will answer questions about the structure of DNA.	Learning	
Structure and Function	HS-LS1-1 Developing and using models ITSE 5b,c	**5. Lesson:** From DNA to Protein: ***Computers will be needed for this activity*** **Objective (s):** Students will be able describe the process of protein synthesis after completing an online simulation. **Learning Activity:** Students will visit https://biomanbio.com/HTML5GamesandLabs/LifeChemgames/protsynthracehtml5page.html to learn how a protein is built from the instructions of DNA. Once student explore the process of transcription and translation through this simulation. Students will explore the structure of RNA and the process of mRNA production, and protein production even further. The teacher should show the videos that are in the links provided and then as a class discuss the process. https://drive.google.com/file/d/11PshCwLyXguhuM_mEB8OcVqq_-dOTXmT/view?usp=sharing the file has the student handout with the links provided. Students can complete the worksheet while going through the learning activity or after the learning activity is completed. **Check for Understanding:** The worksheet can be used as a check for understanding	Assigning Homework and Providing Practice	C Critical Thinking

System and System Models Stability and Change	HS-LS1-4 **HS-LS1-3** Developing and Using Models	**6. Lesson:** Mitosis POGIL **Objectives:** Students will be able to recognize mitosis as a part of the cell cycle and summarize the events that occur during mitosis. Students will be able to explain the importance of mitosis in the life of a cell and for the survival of the organism. **Learning Activity:** https://drive.google.com/file/d/19ZqcX_L6e5y4qBNlvY67I5aSXQ-vGpHG/view?usp=sharing Students will work in groups to complete the POGIL over mitosis with the teacher stopping at the stopping points to clear misconceptions and answer student questions. **Check for understanding:** Students can answer the extension questions to deepen their understanding and for the teacher to help identify any misconceptions	Identifying Similarities and Differences Cues, Questions, and Advance organizers	A D Collaboration Communication, Critical Thinking
Cause and Effect	**HS-LS1-3** HS-LS1-4 Constructing Explanations	**7. Lesson: Tissue Regeneration in Animals** **Objective:** Students will be able to develop a model for the process of growth and development to evaluate the regenerative capabilities of various animals. **Learning Activity:** All animals can heal, and most have the ability to regenerate some of their tissues and body parts. The great diversity of regenerative capabilities among animals is striking—from the feeble ability of humans to the remarkable capacity of some worms to re-form an entire body from a small clump of cells. Students will learn about common cellular and molecular mechanisms underlying all regeneration.	Similarities and Differences Summarizing and Notetaking	C Critical Thinking

UNIT RESOURCES

Vocabulary:

Macromolecules:A large complex molecule such as nucleic acids, proteins, carbohydrates, and lipids
Enzyme: a catalyst (protein) that is used to speed up chemical reactions
Substrate: substance acted on by an enzyme
Monomer: Single building blocks to a macromolecule
Polymer: large molecule made up of smaller subunit monomers
Homeostasis: all living organisms expend energy to keep conditions inside their cells within certain limits.
Nucleotide: The monomer of a nucleic acid
Replication:The process of copying and duplicating a DNA molecule in a semiconservative way
DNA polymerase: an enzyme that assists in DNA replication
Codon: a set of three adjacent nucleotides, also called triplet, on the mRNA strand that will pair with an anticodon of a tRNA molecule
Anticodon: A sequence of three adjacent nucleotides located on one end of the tRNA molecule
Ribosome: *cell organelle consisting of RNA and protein found throughout the cytoplasm in a cell; the site of protein synthesis*
Messenger RNA type of RNA that carries the code or *chemical blueprint* for a specific protein. In the early stages of protein synthesis, the mRNA is synthesized from a DNA template during transcription.
Transfer RNA:A type of RNA involved in protein synthesis, mainly transporting specific amino acid to the ribosome to be added onto the polypeptide chain
Ribosomal RNA: The ribonucleic acid component of the ribosome
Gene: a gene is composed of nucleotides (on a specific site on a chromosome) that is responsible for the physical and heritable characteristics or phenotype of an organism
Mitosis: The process where a single cell divides resulting in generally two identical cells, each containing the same number of chromosomes and genetic content as that of the original cell
Chromosome: A structure within the cell that bears the genetic material
Cell Division: The process in which the *parent* cell divides, eventually giving rise to new *daughter* cells
Centriole - structure in an animal cell that helps organize cell division
Cell theory- fundamental concept of biology that states that all living things are composed of cells; that cells are the basic units of structure and function in living things; and that new cells are produced from existing cells.
Cytoplasm - fluid portion of the cell outside the nucleus
Organelles - specialized structure that performs important cellular functions within a eukaryotic cell.
Cytoskeleton- network of protein filaments in a eukaryotic cell that gives the cell its shape and internal organization and involved in

movement.
Selectively permeable - property of biological membranes that allows some substances to pass across it while other cannot; also called semi permeable membrane
Diffusion- process by which particles tend to move from an area where they are more concentrated to an area where they are less concentrated.
Facilitated diffusion- process of diffusing in which molecules pass across the membrane through the cell membrane channels
Osmosis- diffusion of water through a selectively permeable membrane
Isotonic- when the concentration of two solutions is the same
Hypertonic- when comparing two solutions; the solution with the greater of solutes
Hypotonic- when comparing two solutions, the solution with the lesser concentration of solutes.
Osmotic pressure- pressure that must be applied to prevent osmotic movement across a selectively permeable membrane.
Active transport- the movement of substances against a concentration difference. (requires energy)
Homeostasis-the tendency of an organism or a cell to regulate its internal conditions,

Unit 2: Variation and Inheritance

Content Area: Science	Course: Biology	UNIT: Variation and Inheritance

Unit Description:	Unit Timeline:
In this unit students will investigate how DNA and chromosomes store our genetic information. They will also create models to understand how traits are passed from one generation to the next in sexually reproducing organisms, and then use these models to show how variation is achieved during gamete formation, and make predictions as to the genetic makeup of future generations.	6 Weeks

DESIRED Results

Transfer Goal - ***Students will be able to independently use their learning to……***

1. Ask questions and define problems.
2. Develop and use models.
3. Plan and carry out investigations
4. Analyze and interpret data.
5. Use mathematical and computational thinking.
6. Construct explanations and design solutions
7. Engage in an argument from evidence
8. Obtain, evaluate, and communicate information.

Understandings (Cross Cutting Concepts) – *Students will understand… (Big Ideas)*

1. Patterns
2. Cause and Effect
3. Scale, Proportion, & Quantity
4. Systems & System Models
5. Energy and Matter
6. Structure and Function
7. Stability and Change

Essential Questions: ***Students will keep considering…***

- How are traits passed from one generation to the next?
- How is variation achieved through sexual reproduction?
- How do mutations occur, and what effect do they have on an organism's phenotype?
- How does a eukaryotic organisms regulate gene expression?
- How do environmental factors affect the expression of traits?
-

Anchoring Phenomena: Lactose intolerance (You must put in DCI LS3.A, and grade 9-12 in the drop down menu)

Standards Addressed
Students who demonstrate understanding can: MS-LS3-1:Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.[Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations. (Linked to MLS 9-12-LS3.A.3) **MS-LS3-2:Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation. (Linked to MLS 9-12-LS3.A.2)** HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.] (Link to MLS 9-12-LS3.A.1) **HS-LS3-2: Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.] (Linked to MLS 9-12-LS3.B.4)** HS-LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.[Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.] (Linked to MLS 9-12-LS3.B.5)

Disciplinary Core Ideas **Students will know...**	**Cross Cutting Concepts** **Students will understand….**	**Science and Engineering Practice** **Students will be able to...**
LS3.A: Inheritance of Traits Genes are located in the chromosomes	Structure and Function: Students will understand the relationships	Students develop a model in which they identify the relevant components for making sense of a given phenomenon involving the relationship between mutations

of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. LS3.B: Variation of Traits In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.	between components, including: ● Every gene has a certain structure, which determines the structure of a specific set of proteins. ● Protein structure influences protein function (e.g., the structure of some blood proteins allows them to attach to oxygen, the structure of a normal digestive protein allows it to break down particular food molecules) Observable organism traits (e.g., structural, functional, behavioral) result from the activity of proteins That structural changes to genes (i.e., mutations) may result in observable effects at the level of the organism, including why structural changes to genes:	and the effects on the organism including: 1. Genes located on chromosomes 2. Proteins 3. Traits of organisms. In their model, students describe the relationships between components including: 1. Every gene has a certain structure, which determines the structure of a specific set of proteins. 2. Protein structure influences protein function (e.g., the structure of some blood proteins allows them to attach to oxygen, the structure of a normal digestive protein allows it break down particular food molecules). 3. Observable organism traits (e.g., structural, functional, behavioral) result from the activity of proteins. Students use the model to describe that structural changes to genes (i.e., mutations) may result in observable effects at the level of the organism, including why structural changes to genes: 1. Many affect protein structure and function 2. May affect how proteins contribute to observable structures and functions in organisms. 3. May result in trait changes that are beneficial, harmful, or neutral for the organism. Students use the model, to describe that beneficial, neutral, or harmful changes to protein function can cause beneficial, neutral, or harmful changes in the structure and function of organisms.
LS1.B: Growth and Development of Organisms **Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.** ***(secondary)*** **LS3.A: Inheritance of Traits** **Variations of inherited traits between parent and offspring arise from**	**Cause and Effect:** **Students will understand how each of the examples below either causes or does not cause genetic variation, and the effect they have on the traits found in an organism.** ● **During reproduction (both sexual and asexual), parents transfer genetic information in the form of genes to their offspring.** ○ **Under normal conditions,**	**Students develop a model (e.g., Punnett squares, diagrams, simulations) for a given phenomenon involving the differences in genetic variation that arise from sexual and asexual reproduction. In the model, students identify and describe the relevant components, including:** ● **Chromosome pairs, including genetic variants, in asexual reproduction:** ○ **Parents** ○ **Offspring** ● **Chromosome pairs, including genetic variants, in sexual reproduction:**

genetic differences that result from the subset of chromosomes (and therefore genes) inherited. **LS3.B: Variation of Traits** **In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.**	**offspring have the same number of chromosomes, and therefore genes, as their parents.** ○ **During asexual reproduction, a single parent's chromosomes (one set) are the source of genetic material in the offspring** ○ **During sexual reproduction, two parents (two sets of chromosomes) contribute genetic material to the offspring.**	○ **Parents** ○ **Offspring** **Students use the model to describe a causal account for why sexual and asexual reproduction result in different amounts of genetic variation in offspring relative to their parents, including that:** ● **In asexual reproduction:** ○ **Offspring have a single source of genetic information, and their chromosomes are complete copies of each single parent pair of chromosomes.** ○ **Offspring chromosomes are identical to parent chromosomes.** ● **In sexual reproduction:** ○ **Offspring have two sources of genetic information (i.e., two sets of chromosomes) that contribute to each final pair of chromosomes in the offspring.** ○ **Because both parents are likely to contribute different genetic information, offspring chromosomes reflect a combination of genetic material from two sources and therefore contain new combinations of genes (genetic variation) that make offspring chromosomes distinct from those of either parent.** **Students use cause-and-effect relationships found in the model between the type of reproduction and the resulting genetic variation to predict that more genetic variation occurs in organisms that reproduce sexually compared to organisms that reproduce asexually.**
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)(Note: This	Cause and Effect The cause and effect relationships between DNA, the proteins it codes for, and resulting traits observed in an organism.	Students use models of DNA to formulate questions, the answers to which would clarify: ● The cause and effect relationships between DNA, the proteins it codes for, and resulting traits observed in an organism. ● That the DNA and chromosomes that are used by the cell

Disciplinary Core Idea is also addressed by HS-LS1-1.) 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.	That the DNA and chromosomes that are used by the cell can be regulated in multiple ways and the relationship between the non-protein coding sections of DNA and their functions	can be regulated in multiple ways ● The relationship between the non-protein coding sections of DNA and their functions
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.**	**Cause and Effect** **Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.** **Students will understand the cause of the following processes in sexually reproducing organism and how each affects the characteristics of the organism:** **1. Variations in genetic material naturally result during meiosis when corresponding sections of chromosome pairs exchange places.** **2. Genetic mutations can occur due**	**Students will make a model to support the claim that includes the idea that inheritable genetic variations may result from:** **i.New genetic combinations through meiosis** **ii.Viable errors occurring during replication** **iii.Mutations caused by environmental factors.** **Students will construct explanations to describe* how:** **i.Genetic mutations produce genetic variations between cells or organisms.** **ii.Genetic variations produced by mutation and meiosis can be inherited** **Students use reasoning and valid evidence to construct and engage in an argument that new combinations of DNA can arise from several sources,**

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.	**to:** **a)errors during replication;and/or** **b)environmental factors.** **3. Genetic material is inheritable.**	**including meiosis, errors during replication, and mutations caused by** **environmental factors.** **Students will engage in an argument from evidence to defend a claim against counter claims and critique by evaluating counter-claims and by describing* the connections between the relevant and appropriate evidence and the strongest claim**
LS3.B: Variation of Traits 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.	Scale Proportion Quantity Students will understand how to perform and use appropriate statistical analyses of data at the appropriate scale to determine the proportion and quantity of traits within a population to show how the distribution of traits depends on both genetic and environmental factors.	Students organize the given data by the frequency, distribution, and variation of expressed traits in the population. Students analyze and interpret data to explain the distribution of expressed traits including: 1. Recognition and use of patterns in the statistical analysis to predict changes in trait distribution within a population if environmental variables change 2. Description of the expression of a chosen trait and its variations as causative or correlational to some environmental factor based on reliable evidence
ISTE 3a	plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.	
ISTE 3b	evaluate the accuracy, perspective, credibility and relevance of information, media, data or other resources.	
ISTE 3c	curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.	

Unit 2 Assessment

EVIDENCE of LEARNING			
Understanding Cause and Effect Structure and Function	Standards *MS-LS3-1* ***MS-LS3-2*** ***HS-LS3-2***	**Unit Performance Assessment**:Heredity and Variation **Description of Performance Task:** Students will analyze different methods of inheriting the gene for lactose intolerance. The students will have to create a model of meiosis to explain how variation can be achieved in the offspring, and analyze other sources of variation such as mutation, and environmental causes. **Teacher will assess:** *What criteria will be used in each assessment to evaluate attainment of the desired results?* *1. Students can use a Punnett square to predict the inheritance of traits* *2. Students can use a model of meiosis to explain how variation is achieved* *3. Students can predict how genetics and environmental factors affect the expression of traits in a population.* **Performance:** **Mastery:** Students will show that they really understand when they are able to: Model how variation is achieved in eukaryotic organisms. They must also provide evidence and predict how lactase intolerance is inherited in humans.. **Scoring Guide:** *Rubric on the Assessment*.	**R/R Quadrant** **21 Century** *Rigor & Relevance Framework Quadrant* *4C- critical thinking collaboration communication creativity*

Unit 2: Sample Activities

SAMPLE LEARNING PLAN				
Understanding	**Standards**	**Major Learning Activities:**	**Instructional Strategy Category:**	**R/R Quadrant: 21C:**
Cause and Effect	**MS-LS3-2** Engaging in Argument from evidence	**1. Lesson**: Fruit Fly Traits (Genetics) **Objective**: Students will be able to generate and defend an argument on how the specific trait is inherited and identify the cause and effect relationship through the analysis inheritance patterns for different traits. **Activity:** In this activity the students are given 4 different traits that are inherited in fruit flies. For each trait they are given the phenotypic ratios in the P, F1, and F2 Generation. The student must then determine if the trait is Autosomal, Sex-Linked, Dominant, or Recessive. **Check for understanding:** The students will write a claim, evidence, justification for each of the 4 traits presented in the activity. CER	Non-linguistic representations Generating and Testing Hypotheses	B Critical Thinking Communication
Cause and Effect Scale, Proportion, and Quantity	HS-LS3-3 Analyzing and Interpreting Data	**2. Lesson**: Environmental Influence on Genotypes and Phenotypes. (Tobacco Leaf Lab) **Objective**:Students will be able to determine how light intensity has affected the expression of traits in an organism. through analyzing and interpreting data. **Activity:** The students are given the seeds of tobacco plants that would be predicted to have a 3 green: 1 white phenotypic relationship when it comes to leaf color. The students will conduct an experiment to collect data to see how light intensity affects the color of the leaf. **Check for understanding:** Students will write a CER claim, evidence, justification to support the idea of whether the amount of light affects the color of a leaf.	Non-linguistic representations Generating and Testing Hypotheses	B Critical Thinking Communication

Cause and Effect	**MS-LS3-2** Obtaining, evaluating, and communicating information	**3. Lesson**: Investigating Reproductive Strategies **Objective**:Students will be able to compare and contrast sexual and asexual reproduction, to include the benefits and drawbacks of each method. **Activity:** Students work in pairs to compare five aspects of an organism that reproduces sexually with one that reproduces asexually. As a class, students share their comparisons and generate a list of general characteristics for each mode of reproduction, and discuss the advantages and disadvantages of both. https://betterlesson.com/lesson/634435/investigating-reproductive-strategies **Check for understanding:** Students will create a compare and contrast organizer for the organisms that they studied, and will share the information with the class in a gallery walk structure. Students will provide each other with feedback on their observations.	Cooperative learning Identifying Similarities and Differences Non-linguistic representations	C Collaboration, Communication, Critical Thinking
Cause and Effect	HS-LS3-3 Constructing Explanations ISTE 3a, b, c	**4. Lesson**: Nature and Nurture **Objective**:Students will be able to construct an understanding that both genes and environmental factors influence human behavioral traits **Activity:** Students will work in pairs to research the heritability and environmental factors that influence various human behavioral traits using https://www.omim.org/ . Some of the possible traits they might research include athletic ability, musical talent, and intelligence. Students will then create a graphic organizer to record their research findings. The students will present their findings on a particular trait with three other partners using the Most Important Point structure. Lastly, students will be given a different trait, like susceptibility to cancer, and will need to apply what they have learned to determine what parts are genetic and what parts are environmental. **Check for understanding:** Students will create a claim, evidence, reasoning process to support their claim as how a particular trait is acquired in humans.	Cooperative learning Summarizing and note taking Generating and Testing Hypotheses	*C* *Critical Thinking*

Cause and Effect	**HS-LS3-2** Developing and using models	**5. Lesson**: Meiosis and Fertilization **Objective**:Students will be able to describe how meiosis and fertilization allow for genetic variation in offspring through the development of a model. **Activity:** Students use model chromosomes and answer analysis and discussion questions to learn how each person inherits one copy of each gene from each of his/her parents. As they model meiosis and fertilization, students follow the alleles of three human genes from the parents body cells through gametes to zygotes. In this way, students learn how genes are transmitted from parents to offspring through the processes of meiosis and fertilization. Students analyze the results of crossing over, independent assortment and fertilization to learn how meiosis and fertilization contribute to genetic and phenotypic variation. Students also compare and contrast mitosis and meiosis, and they learn how a mistake in meiosis can result in Down syndrome or death of an embryo. This activity can be used to introduce meiosis and fertilization or to review these processes. **Check for understanding:** Students will be given a cell with a diploid number of 8, and will have to model how genetic variation is achieved through crossing over and independent assortment.	Non-linguistic representations Identifying Similarities and Differences	B Critical Thinking
Cause and Effect	HS-LS3-1 Engaging in argument from evidence Constructing Explanations ISTE 3a, b, c	**6. Lesson**: Regulation of the Lactase Gene **Objective**:Students will be able to describe how the lactase gene is regulated in various ways in different cultures around the world. **Activity:** Students will go to the Howard Hughes Medical Institute website to research how the Lactase gene is regulated in humans. They will then have to form a hypothesis about various control mechanisms, and also compare how these control mechanisms provide different phenotypic ratios in different cultures. **Check for understanding:** Students will present a CER Claim, evidence, reasoning to support how the lactase gene is regulated in a specific culture.	Summarizing and note taking Assigning Homework and Providing Practice Identifying Similarities and Differences Generating and Testing Hypotheses	B Critical Thinking

Structure and Function	MS-LS3-1 Constructing Explanations	**7. Lesson:** Mutations in Genes: How do different types of mutations in genes affect the function of an organism? **Objective:** Students will able to describe how different types of mutations in genes affect the function of an organism through the examination of various mutations. **Activity:** Students will examine the effects of different types of mutations in a DNA sequence on the resulting RNA and protein molecules using a computer simulation to investigate the effect of mutations. **Check for Understanding:** Students will complete an exit slip in which they must explain how a mutation might have caused a phenotypic change to a different type of cell.	Non-linguistic representations Summarizing and note taking Assigning Homework and Providing Practice Generating and Testing Hypotheses	B Critical Thinking
Cause and Effect Structure and Function	MS-LS3-1 Constructing Explanations	**8. Lesson**: Genetic Mutations **Objective**: Students will be able to determine the the effects on the protein produced through comparing and contrasting different forms of gene mutations. **Activity**: Students are given different DNA molecules to analyze and compare to determine the effect of the mutation on the protein that is produced. **Check for Understanding:** The extension questions will be done individually and used as a method to assess the student understanding.	Non-linguistic representations Summarizing and note taking Identifying Similarities and Differences	B Critical Thinking
Cause and Effect	**HS-LS3-2** Constructing Explanations	**9. Lesson:** Chromosomes and Karyotypes **Objective:** Students will use a Karyotype to identify chromosomal disorders, and then create a model of meiosis that would show how this chromosomal disorder could occur. **Activity:** Students will use Pedigrees and Karyotypes to determine why the offspring of a specific set of parents has Down syndrome or cri du chat	Non-linguistic representations Assigning Homework and Providing Practice	B Communication, Critical Thinking

		syndrome, by evaluating the following statements: 1. Down syndrome and cri du chat syndrome are both recessive genetic disorders. Christopher and Jill Miller each carried a recessive allele for these syndromes, and they each passed it down to their children. 2. Down syndrome and cri du chat syndrome are both caused by a chromosomal abnormality. Either the sperm cell from Christopher Miller or the egg from Jill Miller had a damaged, missing, or additional chromosome. 3. Down syndrome and cri du chat syndrome are both caused by toxins in the environment that alter genes. The children were exposed to these toxins before they were born. **Check for Understanding:** Students will complete a CER Claim, evidence, reasoning to support their claim as to how these two syndromes are inherited.	Generating and Testing Hypotheses	

UNIT RESOURCES

Vocabulary:

Genetics- scientific study of heredity
Fertilization- process in sexual reproduction in which male and female reproductive cells join to form a new cell
Trait -specific characteristic of an individual
Hybrid- offspring of crosses between parents with different traits
Gene -sequence of DNA that codes for a protein and thus determines a trait; factor that is passed from parent to offspring
Allele- one of a number of different forms of a gene
Principle of dominance - Mendel's second conclusion, which states that some alleles are dominant and others are recessive
Segregation - separation of alleles during gamete formation
Gametes- sex cell
Probability- likelihood that a particular event will occur
Homozygous- having two identical alleles for a particular gene
Heterozygous- having two different alleles for a particular gene
Phenotype- physical characteristics of an organism
Genotype- genetic makeup of an organism
Punnett square- diagram that can be used to predict the genotype and phenotype combinations of a genetic cross
Independent assortment- One of Mendel's principles that states that genes for different traits can segregate independently during the formation of gametes
Incomplete dominance- situation in which one allele is not completely dominant over another allele
Codominance- situation in which the phenotypes produced by both alleles are completely expressed
Multiple alleles- a gene that has more than two alleles
Polygenic traits- trait that is controlled by two or more genes
Homozygous- term used to refer to chromosomes that each have a corresponding chromosome from the oppositesex parent
Diploid- term used to refer to a cell that contains two sets of homologous chromosomes
Haploid- term used to refer to a cell that contains only a single set of genes
Meiosis- process in which the number of chromosomes per cell is cut in half through the separation of homologous chromosomes in a diploid cell
Tetrad- structure containing 4 chromatids that forms during meiosis
Crossing over- process in which homologous chromosomes exchange portions of their chromatids during meiosis
Zygote - fertilized egg

Transformation- process in which one strain of bacteria is changed by a gene or genes from another strain of bacteria
Promoters- specific region of a gene where RNA polymerase can bind and begin transcription
Introns - sequence of DNA that is not involved in coding for a protein
Exons - expressed sequence of DNA; codes for a protein
Polypeptides- long chain of amino acids that makes proteins
Genetic code- collection of codons of mRNA, each of which directs the incorporation of a particular amino acid into a protein during protein synthesis
Mutation- change in the genetic material of a cell
Point mutation- gene mutation in which a single base pair in DNA has been changed
Frameshift mutations- mutation that shifts the "reading" frame of the genetic message by inserting or deleting a nucleotide
Mutagens- chemical or physical agents in the environment that interact with DNA and may cause a mutation
Polyploidy- condition in which an organism has extra sets of chromosomes.
Operon- in prokaryotes, a group of adjacent genes that share a common operator and promoter and are transcribed into a single mRNA
Operator- short DNA region, adjacent to the promoter of a prokaryotic operon, that binds repressor proteins responsible for controlling the rate of transcription of the operon
RNA interface- introduction of double stranded RNA into a cell to inhibit gene expression
Differentiation- process by which cells become specialized in structure and function
Homeotic genes- a class of regulatory genes that determine the identity of body parts and regions in an animal embryo. Mutations in these genes can transform one body part into another.
Homebox genes- genes that code for transcription factors that activate other genes that are important in cell development and differentiation
Hox genes- a group of homeotic genes clustered together that determine the head to tail identity of body parts in animals. All hox genes contain the homeobox DNA sequence.
Genome- the full set of genetic information that an organism carries in it's DNA
Karyotype- an array of the chromosomes found in an individual's cells at metaphase of mitosis and arranged in homologous pairs and in order

Unit 3: Evolution

Content Area: Science	Course:Biology	UNIT: Evolution

Unit Description: Students will evaluate scientific evidences to be able to describe how populations change over time. They will make, use and analyze models to support the idea that common ancestry and biological evolution are supported by multiple lines of evidence. Examples of the evidence include but are not limited to genetic inheritance, the fossil record, cladograms, and environmental changes. They will also construct explanations based on evidence that natural selection leads to adaptations of populations and that the process of evolution primarily results from four factors: (1) the potential of 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.	**Unit Timeline:** 3 weeks

DESIRED Results

Transfer Goal - ***Students will be able to independently use their learning to……***

1. Ask questions and define problems.
2. Develop and use models.
3. Plan and carry out investigations
4. Analyze and interpret data.
5. Use mathematical and computational thinking.
6. Construct explanations and design solutions
7. Engage in an argument from evidence
8. Obtain, evaluate, and communicate information.

Understandings (Cross Cutting Concepts) – *Students will understand… (Big Ideas)*

1. Patterns
2. Cause and Effect
3. Scale, Proportion, & Quantity
4. Systems & System Models
5. Energy and Matter
6. Structure and Function
7. Stability and Change

Essential Questions: ***Students will keep considering…***

- What evidence for the nature and rates of evolution can be found?
- What is natural selection?
- How does natural selection operate?
- What evidence is there that organisms have changed over time?
- How have organisms changed over time?

Anchoring Phenomena: Antibiotic Resistance - Watch antibiotic resistance evolve - https://www.youtube.com/watch?v=yybsSqcB7mE
Transformation: Dinosaurs to Birds - https://www.youtube.com/watch?v=XAzGC89n0S4
How Did Dinosaurs Evolve Into Birds - https://www.youtube.com/watch?v=0-7iXyYS0uw
The Origin of Birds - HHMI Biointeractive video - https://www.youtube.com/watch?v=z4nuWLd2ivc

Standards Addressed
Students who demonstrate understanding can: **HS-LS4-1 - Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.] (Linked to MLS 9-12-LS4.A.1)** HS-LS4-2 - Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on the number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.] (Linked to MLS 9-12-LS4.B.3) 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. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.] (Linked to MLS 9-12-LS4.B.4) HS-LS4-4 - Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.] (Linked to MLS 9-12-LS4.C.5) HS-LS4-5 - Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.] (Linked to MLS 9-12-LS4.C.6) MS-LS4-3 - Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. (Linked to MLS 9-12 LS4.A.2)

Disciplinary Core Ideas Students will know...	Cross Cutting Concepts Students will understand….	Science and Engineering Practice Students will be able to...
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)**	**Patterns** **Students will be able to observe patterns at multiple spatial and temporal scales and provide evidence for causal relationships relating to biological evolution and common ancestry. Some of these patterns include:** **1. Similarities of the patterns of amino acid sequences, even when DNA sequences are slightly different, including the fact that multiple patterns of DNA sequences can code for the same amino acid** **2. Patterns in the fossil record (e.g., presence, location, and inferences possible in lines of evolutionary descent for multiple specimens)** **3. The pattern of anatomical and embryological similarities.**	**Obtaining, Evaluating, and Communicating Evidence** **Students use at least two different formats (e.g., oral, graphical, textual and mathematical), to communicate scientific information, including that common ancestry and biological evolution are supported by multiple lines of empirical evidence. Students cite the origin of the information as appropriate.** **Students identify and communicate evidence for common ancestry and biological evolution, including:** **1. Information derived from DNA sequences, which vary among species but have many similarities between species** **2. Similarities of the patterns of amino acid sequences, even when DNA sequences are slightly different, including the fact that multiple patterns of DNA sequences can code for the same amino acid** **3. Patterns in the fossil record (e.g., presence, location, and inferences possible in lines of evolutionary descent for multiple specimens)** **4. The pattern of anatomical and embryological similarities.** **Students will identify and communicate connections between each line of evidence and the claim of common ancestry and biological evolution.** **Students communicate that together, the patterns observed at multiple spatial and temporal scales provide evidence for causal relationships relating to biological evolution and common ancestry.**
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 —	Cause and Effect Students understand the cause and effect relationship between genetic variation, the selection of traits that provide comparative advantages, and	Students construct an explanation that includes a description that evolution is caused primarily by one or more of the four factors: 1. the potential for a species to increase in number 2. the heritable genetic variation of individuals in a species

that is, trait variation — that leads to differences in performance among individuals. (HS-LS4-2) 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)	the evolution of populations that all express the trait..	due to mutation and sexual reproduction 3. competition for limited resources 4. the proliferation of those organisms that are better able to survive and reproduce in the environment Students identify and describe evidence to construct their explanation, including that: 1. As a species grows in number, competition for limited resources can arise. 2. Individuals in a species have genetic variation (through mutations and sexual reproduction) that is passed on to their offspring. 3. Individuals can have specific traits that give them a competitive advantage relative to other individuals in the species. Students use a variety of valid and reliable sources for the evidence (e.g., data from investigations, theories, simulations, peer review). Students use reasoning to connect the evidence, along with 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, to construct the explanation. Students describe the following chain of reasoning for their explanation: 1) Genetic variation can lead to variation of expressed traits in individuals in a population. 2) Individuals with traits that give competitive advantages can survive and reproduce at higher rates than individuals without the traits because of the competition for limited resources. 3) Individuals that survive and reproduce at a higher rate will provide their specific genetic variations to a greater proportion of individuals in the next generation. 4) Over many generations, groups of individuals with particular traits that enable them to survive and reproduce in distinct environments using distinct resources can evolve into a different species. Students use the evidence to describe the following in their explanation:

		1. The difference between natural selection and biological evolution (natural selection is a process, and biological evolution can result from that process 2. The cause and effect relationship between genetic variation, the selection of traits that provide comparative advantages, and the evolution of populations that all express the trait.
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-LS4-3) 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 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) Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)	Patterns Students recognize and understand patterns of change in numerical distribution of traits over various time and population scales.	Analyzing and Interpreting Data Students organize data (e.g., using tables, graphs and charts) by the distribution of genetic traits over time. Students describe* what each dataset represents Students perform and use appropriate statistical analyses of data, including probability measures, to determine patterns of change in numerical distribution of traits over various time and population scales. Students use the data analyses as evidence to support explanations about the following: 1). Positive or negative effects on survival and reproduction of individuals as relating to their expression of a variable trait in a population; 2). Natural selection as the cause of increases and decreases in heritable traits over time in a population, but only if it affects reproductive success; and 3) The changes in distribution of adaptations of anatomical, behavioral, and physiological traits in a population.

LS4.C Adaptation 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-LS4-4)	Cause and Effect Students will understand the difference between cause and correlation to construct the explanation about how natural selection provides a mechanism for species to adapt to changes in their environment, including the following elements: 1. Biotic and abiotic differences in ecosystems contribute to changes in gene frequency over time through natural selection. 2. Increasing gene frequency in a population results in an increasing fraction of the population in each successive generation that carries a particular gene and expresses a particular trait. 3. Over time, this process leads to a population that is adapted to a particular environment by the widespread expression of a trait that confers a competitive advantage in that environment.	Constructing Explanations and Designing Solutions Students construct an explanation that identifies the cause and effect relationship between natural selection and adaptation. Students identify and describe empirical evidence to construct an explanation, including: 1. Changes in a population when some feature of the environment changes 2. Relative survival rates of organisms with different traits in a specific environment; 3. The fact that individuals in a species have genetic variation (through mutations and sexual reproduction) that is passed on to their offspring; and 4. The fact that individuals can have specific traits that give them a competitive advantage relative to other individuals in the species Students use a variety of valid and reliable sources for the evidence (e.g., theories, simulations, peer review, students' own investigations) Students use reasoning to synthesize the valid and reliable evidence to distinguish between cause and correlation to construct the explanation about how natural selection provides a mechanism for species to adapt to changes in their environment, including the following elements: 4. Biotic and abiotic differences in ecosystems contribute to changes in gene frequency over time through natural selection. 5. Increasing gene frequency in a population results in an increasing fraction of the population in each successive generation that carries a particular gene and expresses a particular trait. 6. Over time, this process leads to a population that is adapted to a particular environment by the widespread expression of a trait that confers a competitive advantage in that environment.

LAS4.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-LS4-5) 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)	Cause and Effect Students evaluate the degree to which the given empirical evidence can be used to construct logical arguments that identify causal links between environmental changes and changes in the number of individuals or species based on environmental factors that can determine the ability of individuals in a species to survive and reproduce.	Engaging in an Argument from Evidence Students identify the given claims, which include the idea 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 Students identify the given evidence to be evaluated. Students identify and describe additional evidence (in the form of data, information, models, or other appropriate forms) that was not provided but is relevant to the claims and to evaluating the given evidence, including: 1. Data indicating the change over time in: a. The number of individuals in each species; b. The number of species in an environment; c. The environmental conditions. 2. Environmental factors that can determine the ability of individuals in a species to survive and reproduce. Students use their additional evidence to assess the validity, reliability, strengths, and weaknesses of the given evidence, along with its ability to support logical and reasonable arguments about the outcomes of group behavior. Students assess the ability of the given evidence to be used to determine causal or correlational effects between environmental changes, the changes in the number of individuals in each species, the number of species in an environment, and/or the emergence or extinction of species Students evaluate the degree to which the given empirical evidence can be used to construct logical arguments that identify causal links between environmental changes and changes in the number of individuals or species based on environmental factors that can determine the ability of individuals in a species to survive and reproduce
LS4.A Evidence of Common Ancestry and Diversity	Patterns Students use patterns of similarities and	Students organize the given displays of pictorial data of embryos by developmental stage and by organism (e.g., early, middle,

Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully formed anatomy. (MS-LS4-3)	changes in embryo development to describe* evidence for relatedness among apparently diverse species, including similarities that are not evident in the fully formed anatomy (e.g., mammals and fish are more closely related than they appear to be based on their adult features, whales are related to land animals).	just prior to birth) to allow for the identification, analysis, and interpretation of relationships in the data. Students analyze their organized pictorial displays to identify linear and nonlinear relationships, including: 1. Patterns of similarities in embryos across species (e.g., early mammal embryos and early fish embryos both contain gill slits, whale embryos and the embryos of land animals — even some snakes — have hind limbs). 2. Patterns of changes as embryos develop (e.g., mammal embryos lose their gill slits, but the gill slits develop into gills in fish).

Unit 3: Assessment - What would T. rex Taste Like?

<table>
<tr><th colspan="4">EVIDENCE of LEARNING</th></tr>
<tr>
<td>Understanding

Patterns</td>
<td>Standards

HS - LS4-1</td>
<td><u>Unit Performance Assessment</u>: Evolution - What Would T. Rex Taste Like

https://drive.google.com/file/d/1aBXGWm1ZuXiw0R0U228I7UHA7Xe9sCT1/view?usp=sharing

Description of Performance Task: Evolution - What Would T. Rex Taste Like
Students will analyze different lines of evidence to determine relatedness between a T. rex dinosaur and other organisms. They will build a chart making comparisons and identify on a cladogram where certain traits would appear. They will then use their analysis to determine which organism the T. rex is most closely related to and make a prediction as to what T. rex would taste like.

Teacher will assess:
What criteria will be used in each assessment to evaluate attainment of the desired results?
● Students will correctly identify common traits in a table for sharks, tuna, frogs, humans, hare, caiman, parrots, and T. Rex..
● Students will make comparisons from the table and answer questions about the comparisons.
● Students will compare the T-Rex features with those of a Caiman and Parrot.
● Students will complete a cladogram showing specific trait comparisons between a Caiman, Parrot, and T-Rex.
● Students will use this data to identify the common relative to the T. rex. and what T-Rex could have potentially tasted like, providing supporting explanations/evidence.
● Students will use this data to identify what a T-Rex would have tasted like.
<u>Performance:</u>
Mastery:
Students will show understanding when they are able to achieve 80% on the assessment.
● Students can identify common ancestry in a cladogram based on traits.
● Students can make comparisons between related organisms and shared traits.
● Students can correctly construct a cladogram for a Caiman, Parrot, and T-Rex.
● Students can identify the T-Rex as a vertebrate with a bony skeleton, four limbs,</td>
<td><u>R/R Quadrant</u>

<u>21 Century</u>

B

Critical Thinking
Communication</td>
</tr>
</table>

		amniote egg, opening in front of eye, bipedal, 4th and 5th finger lost, and a closer relative to birds than to Caiman with respect to all those traits. ● *Students make the correct correlation between T-Rex's ancestors and what it would have tasted like.* **Scoring Guide:** Scoring guide follows assessment in the assessment document	

Unit 3: Sample Activities

SAMPLE LEARNING PLAN				
Understanding	**Standards**	**Major Learning Activities:**	**Instructional Strategy Category:**	**R/R Quadrant: 21C:**
Patterns	**HS - LS4-1** Obtaining, Evaluating, and Communicting Information	1. **Lesson**: What is a species? **Objective**: Students will: ● recognize that scientists use different definitions of species ● be able to access the strengths and limitations of species definitions depending on their context ● use definitions of species to enhance their understanding of speciation ● understand the concept of taxonomy and biodiversity inventories **Activity:** Using the the What is a species? lesson from ActionBioScience.org, Groups of 4 students will collaborate and share responses to the questions in a table. ● Students will relate a textbook definition of species to four different cases and decide based on the definition if the four different case examples could be considered a species by completing a comparison table. ● Students will then read four different species definitions and determine which definition best helps determine if the four different organisms in question are the same species. ● Students will then individually read a short section about speciation in indigo birds and answer 3 exit slip questions. **Check for understanding:** Responses to two exit slip questions. ● Students will be able to identify if the 2 populations of indigo birds are separate species? Why or why not? ● Students will be able to predict what will happen to these two populations in the future?	*Cooperative learning* *Cues, Questions, and Advance organizers* *Non-linguistic representations* *Identifying Similarities and Differences*	*A, B* *Collaboration, Communication, Critical Thinking*
Patterns	**HS LS4-1**	**2. Lesson**: Using Fossil Evidence to Study Whale Evolution	*Cues, Questions,*	*B, C*

Cause and Effect	HS LS4-4 Obtaining, Evaluating, and Communicating Information-Constructing Explanations and Designing Solutions	**Objective**: Students will be able to hypothesize how the change could have provided an advantage to the whale species through looking at a series of whale fossils, and analyze how the fossils have changed overtime. **Activity:** In pairs, students will cut out the fossils of the 6 different whale species using this file Whale Fossils, and place them in order from oldest to youngest using a rally coach cooperative learning structure. Still using rally coach, they will then complete the similarities and differences chart, comparing the different whale species. Finally, individually, they will formulate a hypothesis, and using the fossil evidence, predict how the changes could have provided an advantage to the species. **Check for understanding:** Students will be able to determine sequence of whale transition based on order of placement. **Exit slip question:** Did whales transition from land to water, or water to land, based on your evidence?	*and Advance organizers* *Non-linguistic representations* *Identifying Similarities and Differences* *Generating and Testing Hypotheses*	*Collaboration, Communication, Critical Thinking*
Patterns	**HS LS4-1** Obtaining, Evaluating, and Communicating Information	**3. Lesson:** Evidence of Evolution **Objective**: Students will understand common ancestry and biological evolution are supported by multiple lines of evidence. **Activity:** Working in pairs, students will analyze evidences for evolution (fossils, comparative anatomy, embryological development, and biochemical evidences) and answer questions and fill in a timeline for various organisms. **Check for understanding:** Students are able to link organisms with common ancestors based on lines of evidence. Correct answers to questions and correct answers to table.	Cues, Questions, and Advance organizers Non-linguistic representations Identifying Similarities and Differences	A Critical Thinking
Patterns	**HS LS4-1** Obtaining, Evaluating, and Communicating Information	**4. Lesson:** Cladogram Lesson Cladogram Student Page **Objective**: During this module students will be able to understand: ● All living things are related by common ancestry. ● Branching diagrams, called cladograms, are used to illustrate evolutionary relationships.	Non-linguistic representations Identifying Similarities and Differences Generating and	B Critical Thinking

		• Cladograms are based on shared, inherited features. • Cladograms refine our ability to understand and interpret evolutionary history **Activity:** Students will work in pairs to complete the lesson. The lesson begins by introducing the three domains of life: bacteria, archaea and eukaryotes, and explains that all living things share a common ancestor. By understanding this single unifying concept, students are able to understand the evolutionary history and relationships of all living things. Students are introduced to the process of illustrating evolutionary relationships with branching diagrams called cladograms. Students learn that once a cladogram has been constructed for a group of organisms, it can be used to answer all kinds of interesting questions based on the shared inherited features of those organisms. An introduction to cladistics, the most commonly used method of classification today. Cladistics organizes living things by common ancestry and evolutionary relationships, enabling us to better understand life's present diversity and evolutionary history. Like other methods of classification, cladistics makes use of the observable features of organisms. Cladistics also allows us to examine the ways in which features change within groups, and to observe patterns of origin and diversification over time. This module presents a simplified version of the process used to generate cladistic analyses and demonstrates its predictive power. Typically dozens or even hundreds of features are examined before a cladogram is produced. Although in this lesson only structural features are used, true cladistic analysis also use biochemical, genetic and even behavioral features. **Check for understanding:** Students will be able to build cladograms using guidelines and specific features.	Testing Hypotheses	
Cross Cutting Concept Addressed Cause and Effect, Patterns	HS LS4-2 HS LS4-4 HS LS4-5 Constructing Explanations	**5. Lesson:** Molecular Genetics of Color Mutations in Rock Pocket Mice **Objective**:Students will be able to connect DNA changes to gene expression and phenotype; and analyze and organize data. **Activity:** This lesson serves as an extension to the short film The Making of the Fittest: Natural Selection and Adaptation (http://www.hhmi.org/biointeractive/making-fittest-natural-selection-and-adaptati	Cooperative learning Cues, Questions, and Advance organizers	B, C, D Collaboration, Communication, Critical

	and Designing Solutions, Engaging in Argument from Evidence	on). Students transcribe and translate portions of the wild-type and mutant rock pocket mouse Mc1r gene. By comparing DNA sequences, students identify the locations and types of mutations responsible for the coat-color change described in the film. Students form a hypothesis to explain how a change in amino acid sequence affects the functionality of the melanocortin 1 receptor (MC1R) protein and how that change might directly affect the coat color of the rock pocket mouse populations. Teacher Page: Molecular Genetics of Color Mutations in Rock Pocket Mice **Check for understanding:** Correct analysis of genes and question answers.	Non-linguistic representations Identifying Similarities and Differences Generating and Testing Hypotheses	Thinking
Patterns	HS LS4-3 Analyzing and Interpreting Data	**6. Lesson:** Evolution In Action **Objective**: Students will be able 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. **Activity:** Students will graph data and analyse the results to determine selection for advantageous traits for cacti and Peccary Pigs in a changing environment. **Check for understanding:** Graphs are done correctly and analyzed for correct selection types for evolution. Responses to questions 1-6 on summary will determine understanding.	Non-linguistic representations Assigning Homework and Providing Practice Identifying Similarities and Differences	A Communication, Critical Thinking
Patterns Cause & Effect Stability & Change	HS-LS4-2 HS-LS4-3 Constructing Explanations and Designing Solutions, Analyzing and Interpreting Data	**7. Lesson:** The Rise of the Dog - Nature Video - "Dogs that Changed the World" **Objective**: Students will: ● construct an explanation based on evidence that the process of evolution primarily results from four factors: reproductive potential, heritable variation, competition for scarce resources, and survival of the fittest. ● understand that natural selection occurs only if there is both genetic (genotypic) variation and differences in its phenotypic expression (leading to an increased allelic frequency in the population).	Cues, Questions, and Advance organizers Non-linguistic representations Summarizing and note taking Generating and Testing	D Collaboration, Communication, Critical Thinking

		Activity: Students will watch the video “Dogs that Changed the World” and make a claim using evidence and reasoning as to how dogs became domesticated. **Check for understanding:** Students will complete a Claim, Evidence, Reasoning about how dogs became domesticated.	Hypotheses	
Cause and Effect Analyzing and Interpreting Data	HS-LS4-2 HS-LS4-3 Constructing Explanations and Designing Solutions, Analyzing and Interpreting Data	**8. Lesson:** Build A Beast Activity **Objective**: Students will be able to create a beast best suited to a specific environment, defend why the adaptations will make their beast successful, and determine how an environmental change may affect their beasts success. **Activity:** This activity demonstrates an important part of evolution: adaptation. Students will create animals with useful adaptations. Students will roll dice to determine where an organism lives, factors about the organism’s environment, diet, and predators. Different adaptations are helpful for different environments, so students will then draw their organism with adaptation that would allow the survival of their organism, and explain why the adaptation would make it successful. **Check for understanding:** Students have designed a beast with reasonable adaptations for their specific environments and appropriately determined how a change could potentially impact the organism.	*Cues, Questions, and Advance organizers* *Non-linguistic representations* *Generating and Testing Hypotheses*	*C* *Creativity, Collaboration, Communication, Critical Thinking*
Analyzing and Interpreting Data Constructing Explanations and Designing Solutions	HS-LS4-3 HS-LS4-4 Analyzing and Interpreting Data, Constructiong Explanations & Designing Solutions	**9. Lesson:** Peppered Moth Lab **Objective**: Students will be able to analyze how color affects an organism's ability to survive in certain environments through a simulation about how predators locate prey in different environments. **Activity:** In pairs, students simulate changes in moth population due to pollution and predation, and observe how species can change over time. Students should then compare with two other groups their responses to question 4 and discuss similarities and differences in their answers. **Check for understanding:** Students are able to make the appropriate prediction for question 4.	Non-linguistic representations Generating and Testing Hypotheses	*B* *Collaboration, Communication, Critical Thinking*

Patterns Cause and Effect	***HS LS4-1*** *HS LS4-2* *HS LS4-3* *HS LS4-4* *HS LS4-5* Obtaining, Evaluating, and Communicting Information Constructing Explanations and Designing Solutions, Analyzing and Interpreting Data, Using Mathematics and Computational Thinking, Engaging in Evidence From Argument	**10. Lesson:** Why Don't Antibiotics Work Like They Used To? **Objective**: Students will be develop ideas on natural selection & evolution including: ● 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. The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. Natural selection leads to 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. ● Changes in the physical environment, whether naturally occurring or human induced, have contributed to the expansion of some species, the emergence of new distinct species, and the decline–and sometimes the extinction–of some species. ● Genetic information provides evidence of evolution; multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. . **Activity:** This high school unit on natural selection and evolution starts out with students exploring the case of a young girl with a life-threatening infection of pan-resistant bacteria. This case sparks questions that lead them to investigate the growing prevalence of such cases and the discrepancies between antibiotic use in their communities and CDC recommendations. As they develop a model to explain how bacteria populations change over time, they expand their investigations to look at whether similar population changes are occurring in a population of birds (Juncos). Student Page: Why Don't Antibiotics Work Teacher Page: Why Don't Antibiotics Work	*Cooperative learning* *Cues, Questions, and Advance organizers* *Non-linguistic representations* *Identifying Similarities and Differences* *Generating and Testing Hypotheses*	*B, C, D* *Collaboration, Communication, Critical Thinking*

		Skeleton: Why Don't Antibiotics Work Consumable List: Why Don't Antibiotics Work **Check for understanding:** Students are able to provide a scientific claim that answers their question, supported with evidence.		

UNIT RESOURCES

Vocabulary:

Theory of Evolution—change over time the process by which present organisms have descended from ancient organisms
Artificial selection—nature provides the variations and humans selected the variations they found useful
Adaptation—heritable characteristics that increases an organism's ability to survive and reproduce in an environment
Fitness—how well an organism can survive and reproduce in its environment
Natural selection—process by which organisms that are most suited to their environment survive and reproduce most successfully
Homologous structures—structures that are similar in different species of common ancestry
Analogous structures—body parts that share a common function but not structure
Vestigial structures—structure that is inherited from ancestors but has lost much or all of its original function
Embryology—the study of embryos
Gene pool—all the genes including all the different alleles for each gene that are present in a population at any one time
Relative frequency—the amount of a trait of interest in a population
Directional selection—the shifts of a trait to a more favorable attribute
Stabilizing selection—form of natural selection in which individuals near the center of a distribution curve have higher fitness than that of individuals at either end of the curve
Disruptive selection—natural selection in which individuals at the upper and lower ends of the curve have higher fitness than individuals near the middle
Genetic Drift—random change in a allele frequency caused by a series of chance occurrences that cause an allele to become more or less common in a population
Bottleneck effect—a change in the allele frequency following a dramatic reduction in the size of a population
Founder effect—allele frequencies change as a result of the migration of a small subgroup of a population
Genetic equilibrium—situation in which allele frequencies in a population remain the same
Hardy Weinberg principle—principle that states that allele frequencies in a population remain constant unless one or more factors cause those frequencies to change
Speciation—formation of a new species
Reproductive isolation—separation of a species or population so that they no longer interbreed and evolve into two separate species
Behavioral isolation—form of reproductive isolation in which two populations develop differences in courtship rituals or other behaviors that prevent from breeding
Geographic isolation—form of reproductive isolation in which two populations are separated by geographic barriers such as rivers, mountain, or bodies of water leading to the formation of two separate species
Temporal isolation—form of reproductive isolation in which two or more species reproduce at different times

Radiometric dating—method for determining the age of a sample from the amount of radioactive isotope o the nonradioactive isotope of the same element in a sample
Half life—length of time required for half of the radioactive atoms in a sample to decay
Geologic time scale—timeline used to represent earth's history
Era—major division of geological time; usually divided into two or more periods
Period—division of geological time into which eras are subdivided
Plate tectonics—geological processes such as continental drift, volcanoes, and earthquakes resulting from plate movement
Macroevolution—changes in anatomy, phylogeny, ecology, and behavior that take place in clades larger than a single species
Mass extinction—event during which many species become extinct during a relatively short period of time
Gradualism—the evolution of a species by gradual accumulation of small genetic changes over long periods of time
Punctuated equilibrium—pattern of evolution in which long stable periods are interrupted by brief periods of more rapid changes
Adaptive radiation—process by which a single species or a small group of species evolves into several different forms that live different ways
Convergent evolution—process by which unrelated organisms independently evolve similarities when adapting to similar environments
Coevolution—process by which two species evolve in response to changes in each other over time

Unit 4: Carbon and Life

Content Area: Science	Course: Biology	UNIT: Carbon and Life

Unit Description: Students will model the transfer of energy through the processes of photosynthesis and cellular respiration. Students will illustrate how photosynthesis transforms light energy into stored chemical energy. Students will understand the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.	**Unit Timeline:** 4 weeks

DESIRED Results

Transfer Goal - ***Students will be able to independently use their learning to……***

1. Ask questions and define problems.
2. Develop and use models.
3. Plan and carry out investigations
4. Analyze and interpret data.
5. Use mathematical and computational thinking.
6. Construct explanations and design solutions
7. Engage in an argument from evidence.
8. Obtain, evaluate, and communicate information.

Understandings (Cross Cutting Concepts) – *Students will understand… (Big Ideas)*

1. Patterns
2. Cause and Effect
3. Scale, Proportion, & Quantity
4. Systems & System Models
5. Energy and Matter
6. Structure and Function
7. Stability and Change

Essential Questions: ***Students will keep considering…***
What process causes a tree to grow so large?
How does a tree fit into the cycling of carbon in an ecosystem?
What would it take for a human to be capable of photosynthesis?
What impact would a photosynthesizing human have on the ecosystem?

The phenomena to anchor this unit here. Tree: Tree Mass Photosynthesizing slug: Slug

Standards Addressed		
Students who demonstrate understanding can: ● **HS-LS1-5 Link to MLS9-12-LS1-C6 : Students will use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]** ● **HS-LS1-7 Link to MLS9-12-LS1-C7 Students will use a model to illustrate that cellular respiration is a chemical process that transforms chemical energy by breaking down the bonds in food molecules and making new bonds in structures for the organism. y.[Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]** ● HS-LS2-5 Link to MLS9-12-LS1-C7 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.] (not assessed at this level but it is at sustainability unit)		
Disciplinary Core Ideas **Students will know...**	**Cross Cutting Concepts** **Students will understand….**	**Science and Engineering Practice** **Students will be able to...**
LS1.C 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)	Students identify the following relationship: Sugar and oxygen are produced by carbon dioxide and water by the process of photosynthesis. Students make the connection between he transfer of matter and flow of energy between the organism and its environment during photosynthesis; and Photosynthesis results in the storage of energy in the difference between the energies of the chemical bonds of the inputs (carbon dioxide and water) and outputs (sugar and oxygen)	Use a model based on evidence to illustrate the relationships between systems or between components of a system. From the given model, students identify and describe* the components of the model relevant for illustrating that photosynthesis transforms light energy into stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen, including: i.Energy in the form of light; ii.Breaking of chemical bonds to absorb energy;

		iii.Formation of chemical bonds to release energy; iii.Matter in the form of carbon dioxide, water, sugar, and oxygen.
LS1.C: Organization for Matter and Energy Flow in Organisms As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS-1-7)	**Energy and Matter Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems. Students make the connection that the chemical reaction of oxygen and food molecules releases energy as the matter is rearranged, existing chemical bonds are broken, and new chemical bonds are formed, but matter and energy are neither created nor destroyed.**	**From a given model, students identify and describe* the components of the model relevant for their illustration of cellular respiration, including:** **i. Matter in the form of food molecules, oxygen, and the products of their reaction (e.g., water and CO2);** **ii. The breaking and formation of chemical bonds;** **iii. Energy from the chemical reactions.** **From the given model, students describe* the relationships between components, including:** **i. Carbon dioxide and water are produced from sugar and oxygen by the process of cellular respiration** **ii. The process of cellular respiration releases energy because the energy released when the bonds that are formed in CO2 and water is greater than the energy required to break the bonds of sugar and oxygen.**
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and	**The exchange of carbon (through carbon-containing compounds) between organisms and the environment; and the role of storing carbon in organisms (in the form of carbon-containing compounds) as part of the carbon cycle**	**Students use evidence to develop a model in which they identify and describe* the relevant components, including:** **i. The inputs and outputs of photosynthesis** **ii. The inputs and outputs of cellular respiration**

biological processes. PS3.D: Energy in Chemical Processes The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary)		**iii. The biosphere, atmosphere, hydrosphere, and geosphere** **iii. Students describe* the contribution of photosynthesis and cellular respiration to the exchange of carbon within and among the biosphere, atmosphere, hydrosphere, and geosphere in their model.** **iv. Students make a distinction between the model's simulation and the actual cycling of carbon via photosynthesis and cellular respiration.**

Unit 4 Assessment:

EVIDENCE of LEARNING			
Understanding *5* Matter and Energy	Standards **HS-LS1-5** **HS-LS1-7**	**Unit Performance Assessment**: Unit 4 PE: Super Slugalicious **Description of Performance Task:** *Students will create a model that depicts the relationship between photosynthesis and respiration.* **Teacher will assess:** Models could include diagrams, chemical equations, and/or conceptual models Model Checklist: ● Inputs and outputs of matter ● Reactants and products of photosynthesis ● Reactants and products of cellular respiration ● Chloroplast referenced ● Mitochondria referenced Emphasis is on the conceptual understanding of the inputs and outputs of the process of photosynthesis and respiration, should not include identification of the steps or specific processes involved in cellular respiration or photosynthesis **Performance:** **Mastery:** Students will model their understand of the relationship between photosynthesis and respiration. **Scoring Guide:** Model Rubric	**R/R Quadrant** B **21 Century** *critical thinking* *collaboration* *communication*

Unit 4: Sample Activities

SAMPLE LEARNING PLAN				
Understanding	**Standards**	**Major Learning Activities:**	**Instructional Strategy Category:**	**R/R Quadrant: 21C:**
Energy and Matter	**HS-LS1-5** Asking Questions	**1. Lesson**: Photosynthesis Anticipation Guide **Objective**: Students will be able to assess their current level of understanding of photosynthesis. **Activity:** Students are given various statements about photosynthesis and must choose if they agree or disagree with the statements. They can then return to the document at the end of the unit to determine if they were correct or not and check their understanding of the statements. **Check for understanding:** Students should revisit this anticipation guide at the end of the unit before their unit exam.	Cues, Questions, and Advanced Organizers	*A* *Critical Thinking*
Energy and Matter	**HS-LS1-5** Analyzing and Interpreting Data	**2. Lesson:** Why are Plants Green? **Objectives:** Students develop an understanding of light, color, and pigments in photosynthesis through graphing and interpreting absorption spectra data for chlorophylls. **Activity:** This is a partial inquiry lesson where students begin a study of pigments by making and analyzing absorption spectra graphs for chlorophyll a and chlorophyll b. Use this lesson before any assignments or discussion on pigments.	generating and testing hypotheses	*A* *Critical Thinking*
Energy and Matter	**HS-LS1-5** Analyzing and Interpreting Data	**3. Lesson**: Plant Pigments and Photosynthesis **Objective**: Students compare the pigments in two different leaves. **Activity:** Students use chromatography to determine the pigments that are found in two different types of leaves. This follows “Why are Plants Green”	Generating and Testing Hypotheses	*D* *Communication* *Collaboration* *Critical Thinking*

		activity. The students can actually see the pigments that make up the leaf.		
Energy and Matter	**HS-LS1-5** Asking Questions Planning and Carrying Out Investigations Engaging in Argument Analyzing and Interpreting Data Constructing Explanations	**4. Lesson**: Leaf Disk Photosynthesis **Objective**: Students will be able to design, synthesize, and evaluate their own lab to address what factors affect the rate of photosynthesis and prepare an argument to support their claim. **Activity:** Students will design and conduct an experiment to determine what factors affect the rate of photosynthesis. Students will design and conduct their own laboratory investigation on the factors that affect photosynthetic rate. Students will gather evidence, make a claim, and justify their claim both in writing and to their colleagues along with receiving feedback. Students will have the opportunity to formally defend their claim and peer critique their own work. There may be an opportunity to share the results with other biology classes.	*Argumentative Writing* *Feedback* *Generating and Testing Hypotheses*	*D* *Communication* *Collaboration* *Critical Thinking*
Structure and Function	**HS-LS1-5** Developing and Using Models	**5. Lesson**: What's in a Leaf? **Objective**: Students will be able to analyze the relationship between the structure and function of the leaf. **Activity:** Students analyze pictures of the leaf and the cross-section of the dicot leaf to determine the functions of the tissues. (An optional activity would be to have the students look at the cross-section of a dicot leaf under the microscope.) Students could also look at the underside of various living leaves to observe the stomates and create a model on how the stomates operate and incorporate homeostasis in their discussion.	Identifying Similarities and Differences	*D* *Communication* *Collaboration* *Critical Thinking*

Energy and Matter	**HS-LS1-7** Planning and Carrying out Investigations	**6. Lesson (2 day lesson)**: Alcoholic Fermentation Lab **Objective**: Students will be able to create an experimental design used to determine if apple juice ferments. **Objective, Part Two**: Students will carry out an experiment to test a hypothesis that addresses carbon dioxide production by yeast during fermentation. **Activity:** When observing the bubbles given off in part one, various questions should come to mind. Does the rate of bubble production increase or decrease over time? What would happen to the rate of bubbles given off if more yeast were present in the mixture or if the sugar content of the apple juice was less? This lesson could be adapted to address any factor that affects respiration such as the type of sugar that is used such as Splenda or fructose. In part 2 of the lab students are generating their own experiment.	Cues and questions Generating and Testing Hypotheses Argumentative Writing Cooperative Learning	*D* *Communication* *Collaboration* *Critical Thinking*
Systems and system models	**HS LS1-7** Developing and Using Models	**7. Lesson**: Respiration POGIL **Objective**: Students will be able to determine how energy is transferred and transformed in living organisms. **Activity:** Students will work through 3 models on glycolysis, Krebs cycle, and the electron transport chain and determine the input and output of each model.	Identifying Similarities and Differences	*D* *Critical Thin king*
Energy and Matter	**HS-LS1-5** Asking Questions Planning and Carrying Out Investigations Engaging in Argument	**8. Lesson**: Leaf Disk Photosynthesis **Objective**: Students will be able to design, synthesize, and evaluate their own lab to address what factors affect the rate of photosynthesis and prepare an argument to support their claim. **Activity:** Students will design and conduct an experiment to determine what factors affect the rate of photosynthesis. Students will design and conduct their own laboratory investigation on the factors that affect photosynthetic rate.	*Cooperative learning* *Argumentative Writing* *Feedback* *Generating and Testing Hypotheses*	*D* *Communication* *Collaboration* *Critical Thinking*

	Analyzing and Interpreting Data Constructing Explanations	Students will gather evidence, make a claim, and justify their claim both in writing and to their colleagues along with receiving feedback. Students will have the opportunity to formally defend their claim and peer critique their own work. There may be an opportunity to share the results with other biology classes.		
Systems	**HS-LS1-5** **HS-LS1-7** Obtaining, evaluating, and using information	**8. Lesson**: Cell Energy Cycle Gizmo **Objective**:Students will be able to examine the molecules that play a role in the process of photosynthesis and discover how the process creates an energy source that can support the functions of most of the Earth's organisms. **Activity:** Students explore the processes of photosynthesis and respiration that occur within plant cells. The cyclical nature of the two processes can be constructed visually, and the photosynthesis and respiration equations can be balanced in a descriptive and numerical format. **Check for Understanding:** Students will take the end of exercise quiz that is provided within the activity.	Non-linguistic representations Assigning Homework and Providing Practice	B *Critical Thinking*
Systems	HS-LS2-5 Carrying out Investigations	**9. Lesson**: Determining the Rate of Cellular Respiration **Objective**: Students will determine how temperature affects respiration rate in germinating seeds. **Activity:** The effects that temperature has on the rate of cell respiration will be determined in germinated and non-germinated seeds. An Oxygen Gas Sensor is used to measure the concentration of oxygen gas within a sealed container and a Carbon Dioxide Sensor will be used to measure the concentration of carbon dioxide gas. As an assessment portion of this lab, the students may design and conduct an experiment that compares the respiration rate among various types of seeds.	Generating and Testing Hypotheses Similarities and Differences	*D* Communication Collaboration Critical Thinking

UNIT RESOURCES

Vocabulary:

Adenosine triphosphate (ATP)-compound used by cells to store and release energy
Heterotroph -organism that obtains food by consuming other living things; also called a consumer
Autotroph - organism that is able to capture energy from sunlight or chemicals and use it to produce its own food from inorganic compounds; also called a producer.
Photosynthesis-the process used by plants and other autotrophs to capture light energy and use it to power chemical reactions at convert carbon dioxide and water into oxygen and energy rich carbohydrates such as sugars and starches.
Pigment- light absorbing molecule used by plants to gather the sun's energy.
Chlorophyll- principal pigment of plants and other photosynthetic organisms
Chloroplast- organelle found in cells of plants and some other organisms that capture the energy from sunlight and convert it into chemical energy
Mitochondria -cell organelle that converts the chemical energy stored in food into compounds that are more convenient for the cell to use.
Lipid bilayer- flexible double layered sheet that makes up the cell membrane and forms a barrier between the cell and its surroundings
Thylakoid - saclike photosynthetic membrane found in chloroplast
Stroma- fluid portion of the chloroplast; outside of the thylakoids
NADP + carrier- molecule that transfers high energy electrons from chlorophyll to other molecules
Light dependant reaction set of reactions in photosynthesis that use energy from light to produce ATP and NADPH
Light independent reaction set of reactions in photosynthesis that do not require light; energy from ATP and NADPH is used to build high energy compounds such as sugar; also called the Calvin cycle.
Photosystems- cluster of chlorophyll and proteins found in thylakoids
Electron transport chain - series of electron carrier proteins that shuttle high energy electrons during ATP generating reactions
ATP synthase - cluster of proteins that span the cell membrane and allow hydrogen ions to pass through it
Calvin cycle- light independent reactions of photosynthesis in which energy from ATP and NADPH is used to build high energy compounds such as sugar.
Calorie- measure of heat energy in food; equivalent to 1000 calories
Cellular respiration- process that releases energy by breaking down glucose and other food molecules in the presence of oxygen
Aerobic- process that requires oxygen
Stomata - openings in the leaf, made and regulated by guard cells that regulate gas exchange and water loss in the leaf

Unit 5: Sustainability

Content Area: Science	Course:Biology	UNIT: Sustainability

Unit Description: Students will understand how organisms interact with each other and the impact humans can have on these interactions. They will also understand how energy and matter flow within and through the biosphere. Students will also understand the role that biodiversity plays in the sustainability of an ecosystem.	Unit Timeline: 4 weeks

DESIRED Results

Transfer Goal - ***Students will be able to independently use their learning to……***

1. Ask questions and define problems.
2. Develop and use models.
3. Plan and carry out investigations
4. Analyze and interpret data.
5. Use mathematical and computational thinking.
6. Construct explanations and design solutions
7. Engage in an argument from evidence.
8. Obtain, evaluate, and communicate information.

Understandings (Cross Cutting Concepts) – *Students will understand… (Big Ideas)*

1. Patterns
2. Cause and Effect
3. Scale, Proportion, & Quantity
4. Systems & System Models
5. Energy and Matter

6. Structure and Function
7. Stability and Change

Essential Questions: ***Students will keep considering…***

- How many deer can live in my subdivision?
- From where does the energy you (and all other life) use to maintain homeostasis come?
- What happens to elements and nutrients stored in an organism when it dies?

Anchoring Phenomena: Urban Deer Picture

Standards Addressed		
Students who demonstrate understanding can: ● HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.] (Link to 9-12-LS2-A1) ● HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.] (Link to 9-12-LS2-B3) ● HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.] (Link to 9-12-LS2-B4)		
Disciplinary Core Ideas **Students will know...**	**Cross Cutting Concepts** **Students will understand….**	**Science and Engineering Practice** **Students will be able to...**
LS2.A	Scale, Proportion, and Quantity	Using Mathematics and Computational Thinking

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)	The population changes gathered from historical data or simulations of ecosystems at different scales Some factors have larger effects than do other factors. Factors are interrelated. The significance of a factor is dependent on the scale (e.g., a pond vs. an ocean) at which it occurs.	Students identify and describe the components in the given mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) that are relevant to supporting given explanations of factors that affect carrying capacities of ecosystems at different scales. The components include: 1. The population changes gathered from historical data or simulations of ecosystems at different scales; and 2. Data on numbers and types of organisms as well as boundaries, resources, and climate Students identify the given explanation(s) to be supported, which include the following ideas: Factors (including boundaries, resources, climate, and competition) affect carrying capacity of an ecosystem, and: 1. Some factors have larger effects than do other factors. 2. Factors are interrelated. 3. The significance of a factor is dependent on the scale (e.g., a pond vs. an ocean) at which it occurs. Students use given mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) of ecosystem factors to identify changes over time in the numbers and types of organisms in ecosystems of different scales. Students analyze and use the given mathematical and/or computational representations. 1. To identify the interdependence of factors (both living and nonliving) and resulting effect on carrying capacity; and 2. As evidence to support the explanation and identify the factors that have the largest effect on the carrying capacity of an ecosystem for a given population
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: 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	Energy and Matter the idea that matter flows between organisms and their environment. the idea that energy flows from one trophic level to another as well as through the environment.	Using Mathematical and Computational Thinking Students identify and describe the components in the mathematical representations that are relevant to supporting the claims. The components could include relative quantities related to organisms, matter, energy, and the food web in an ecosystem.

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)	the energy not transferred to higher trophic levels but which is instead used for growth, maintenance, or repair, and/or transferred to the environment, and the inefficiencies in transfer of matter and energy.	Students identify the claims about the cycling of matter and energy flow among organisms in an ecosystem. Students describe how the claims can be expressed as a mathematical relationship in the mathematical representations of the components of an ecosystem. Students use the mathematical representation(s) of the food web to: 1. Describe the transfer of matter (as atoms and molecules) and flow of energy upward between organisms and their environment; 2. Identify the transfer of energy and matter between trophic levels; and 3. Identify the relative proportion of organisms at each trophic level by correctly identifying producers as the lowest trophic level having the greatest biomass and energy and consumers decreasing in numbers at higher trophic levels. Students use the mathematical representation(s) to support the claims that include the idea that matter flows between organisms and their environment. Students use the mathematical representation(s) to support the claims that include the idea that energy flows from one trophic level to another as well as through the environment. Students analyze and use the mathematical representation(s) to account for the energy not transferred to higher trophic levels but which is instead used for growth, maintenance, or repair, and/or transferred to the environment, and the inefficiencies in transfer of matter and energy.
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.	Systems and System Models the actual cycling of carbon via photosynthesis and cellular respiration. the contribution of photosynthesis and cellular respiration to the exchange of carbon within and among the biosphere, atmosphere, hydrosphere, and geosphere	Developing and Using Models Students use evidence to develop a model in which they identify and describe the relevant components, including: 1. The inputs and outputs of photosynthesis; 2. The inputs and outputs of cellular respiration; and 3. The biosphere, atmosphere, hydrosphere, and geosphere. Students describe relationships between components of their model,

(HS-LS2-5) PS3.D: Energy in Chemical Processes The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary) (HS-LS2-5)	in their model.	including: 1. The exchange of carbon (through carbon-containing compounds) between organisms and the environment; and 2. The role of storing carbon in organisms (in the form of carbon-containing compounds) as part of the carbon cycle. Students describe the contribution of photosynthesis and cellular respiration to the exchange of carbon within and among the biosphere, atmosphere, hydrosphere, and geosphere in their model. Students make a distinction between the model's simulation and the actual cycling of carbon via photosynthesis and cellular respiration.

Unit 5: Assessment

EVIDENCE of LEARNING			
Understanding 3	Standards **HS-LS2-1** **HS-LS2-4** **HS-LS2-5**	**Unit Performance Assessment**: **Description of Performance Task:** Sustainability Unit Performance Event Students interpret a food chain for energy flow and matter cycling. Then they apply the concepts of Systems and System Models when they create their own food chain model. Demonstrating their understanding of Scale, Proportion, and Quantity they perform a CER to evaluate changes in energy and biomass in their model. Students will then use Mathematics and Computational Thinking to determine the viability of a change in the number of predators. **Teacher will assess:** What criteria will be used in each assessment to evaluate attainment of the desired results? - Students description about which organisms are undergoing photosynthesis and cellular respiration from a model and explain how they know. - Student's understanding about the flow of carbon through a biosphere in a food chain through their creation of a system model. - Student's mathematical representations to account for the energy not transferred to higher trophic levels but which is instead used for growth, maintenance, or repair and/or transferred to an environment, and the inefficiencies in transfer of matter and energy. **Performance:** **Mastery:** Students will show that they really understand when they are able to explain using correctly labeled models that matter (carbon and other nutrients)cycles through an ecosystem. Students will also use a mathematical model to show how energy is lost as it moves up trophic levels **Scoring Guide:** **Model Rubric** **CER Rubric**	**R/R Quadrant** Quadrant D **21 Century** Critical Thinking

Unit 5: Sample Activities

SAMPLE LEARNING PLAN				
Understanding	**Standards**	**Major Learning Activities:**	**Instructional Strategy Category:**	**R/R Quadrant: 21C:**
Developing and Using Models Analyzing and Interpreting Data Computational Thinking	LS2-1 Cause and Effect System Model Stability and Change *ISTE Standard addressed*	**1. Lesson**: Lesson of the Kaibab Deer https://www.biologycorner.com/worksheets/kaibab.html **Objective**: Students will be able to…. • Graph data on the Kaibab deer population of Arizona from 1905 to 1939 • Demonstrate understanding of factors responsible for the changing populations by graphing carrying capacity. • Determine the carrying capacity of the Kaibab Plateau **Activity:** Using Historical information students will develop a graphical model of the carrying capacity of the Kaibab Plateau. Activity also emphasizes human impact on the Kaibab Plateau **Check for understanding:** Graph clearly shows carrying capacity. Students can explain how humans affected the carrying capacity of the Kaibab Plateau by changing environmental conditions	Cues, Questions, and Advance organizers Non-linguistic representations Generating and Testing Hypotheses	R/R Quadrant C Communication, Critical Thinking
Cross Cutting Concept Addressed Developing and Using Models Analyzing and Interpreting Data	**LS2-1** Stability and Change Cause and Effect System and System Model	**2. Lesson:** Oh Deer- Activity on limiting and carrying capacity **https://drive.google.com/open?id=1Z0e-dzB-fJjRJeAzr_R2qlRu3hhiwxoU** **Objective:** Students will understand how limiting factors affect a population through collecting data and graphing the changing population of deer and graphically understand carrying capacity **Activity:** Students will role play deer and various limiting factors (food, habitat,etc) The 'deer' will obtain needed factors and live or die and return to the environment. Students will collect data, create a graph and answer	Non-linguistic representations	R/R Quadrant C Collaboration, Communication, Critical Thinking

Mathematics and Computational Thinking		comprehension questions. Activity needs a large space or be done outdoors. **Check for Understanding:** HW: Graph should clearly show changes in population and indicate various stages of population growth. Comprehension question answers should reflect an understanding of how matter cycles through an ecosystem		
Cross Cutting Concept Addressed Developing and Using Models constructing Explanations	**LS2-4** Systems and System Models *ISTE Standard addressed*	**3. Lesson:** Understanding Nutrient Cycles https://drive.google.com/file/d/1S1D1yaSxBvXTdXkMvN9tJbp919UPQB2o/view?usp=sharing **Objective**: Student create a model that shows how essential nutrients (carbon, phosphorus, nitrogen) cycle through an ecosystem **Activity:** Using the internet, students will research how nutrients cycles through ecosystems and complete diagrams and comprehension questions **Check for understanding:** Student diagrams will be correctly labeled showing how nutrients flow through an ecosystem	Cues, Questions, and Advance organizers Non-linguistic representations Identifying Similarities and Differences	R/R Quadrant B Creativity, Collaboration, Communication, Critical Thinking
Patterns Energy and Matter Scale, Proportion and Quantity	**LS2-4** Analyzing and Interpreting Data Developing and Using Models	**4. Lesson:** How Does Energy Flow in an Ecosystem https://drive.google.com/open?id=1UnTiFqWv9HW8N8itGLQSotWpoivGUtDi **Objective:** Students will demonstrate their understanding of food chains and foods webs to then understand how energy is transferred through an ecosystem. Energy pyramids and the 10% rule of energy transfer will be analyzed from lab data **Activity:** Students will complete a lab activity in which the transfer of water is used to to represent the transfer of energy. Students use cups with holes in the the bottom to transfer water(energy) between multiple individuals. (trophic levels). Students record data and develop a mathematical model for how energy is lost as it moves of the food chain.	Nonlinguistic representation	R/R Quadrant D
Cross Cutting Concept	**LS2-5**	**5. Lesson**: Carbon Cycle Role Playing	Nonlinguistic representation	R/R Quadrant

Addressed Developing and Using Models Constructing Explanations Obtaining, Evaluating, and Communicating Information	System Models Stability and Change *ISTE Standard addressed*	https://www.calacademy.org/sites/default/files/assets/docs/pdf/048_carboncycleroleplayredesign10nov2014mks.pdf **Objective**: Students will be able to: 1. recognize that there is a finite amount of carbon on earth. 2. model how carbon moves around in the environment, from one place to another. 3. identify how humans influence the carbon cycle. **Activity:** Using role playing cards, students will role play how carbon moves through the biosphere. This activity is done in a large space or outside **Check for understanding:**		C Creativity, Collaboration, Communication, Critical Thinking
Developing and Using Models	System Models Stability and Change	**6. Lesson: Where Does the Carbon Go? (Presentation)** https://docs.google.com/document/d/1LiphRxUyyUtMm7mGWLgOWUFlJuEMO4oPjnbZJZ88nqA/edit?usp=sharing **Objective:** Students will create a graphic or visual representation of the role that photosynthesis and cellular respiration play in the cycling of carbon through the biosphere, atmosphere , hydrosphere and geosphere. **Activity:** Using a format of their choice(movie, prezi, infographic, poster, etc) students will detail how photosynthesis and cellular respiration are related and the role that carbon plays in both processes. They will further explain how the processes move carbon through the biosphere, atmosphere , hydrosphere and geosphere.	nonlinguistic relationship	R/R Quadrant D Creativity, Collaboration, Communication, Critical Thinking
Developing and Using Models	**LS2-6**	**7. Lesson: Ecological Succession** **https://drive.google.com/open?id=103lEgHxOFgSEalwX7E95t0floufPELSh** **Objective:** Students will understand how ecological succession maintains		R/R Quadrant B

		relatively consistent numbers and types of organisms in stable conditions but changing condition may result in a new ecosystem **Activity:** Students will use the high school as a model and predict what would happen if maintenance stopped at the high school (no mowing, sweeping, trash pick up , etc. They will then use background information to develop a working definition of ecological succession and associated processes **Check for Understanding:** Student answers will indicate an understanding of the concept of ecological succession by making a model to show the before and after effects of the maintenance stoppage.		Creativity, Collaboration, Communication, Critical Thinking
Mathematics and Computational Thinking Obtaining, Evaluating, and Communicating Information Engaging in Argument from Evidence	Patterns Scale Proportion Quantity Stability and Change	**Lesson: Tongass Forest Case Study** https://drive.google.com/open?id=1V3IWcEWi-Qi2fNjg3Gt6M5MXcoNJ5FkS **Objective: Students evaluate relevant forest policy and management and discuss the related challenges. They then use math to estimate tree height and board feet in three different management areas from angle measurements obtained using a clinometer. Finally they consider the importance of tree height and forest management on ecological relationships among wildlife and their habitat. The case can be used as an introduction to natural resource management and the importance of multiple use management strategies.** **Activity: Discuss challenges related to natural resource management.** • **Define several terms related to forestry, ecology, and conservation biology.** • **Understand concepts related to expenses and revenue in the context of resource extraction.** • **Understand the effects of habitat (i.e., forest types) on interactions among animals in a food web.** • **Develop management suggestions based on results and by considering habitat-related policy information and wildlife habitat requirements.** • **Estimate a product using a computer spreadsheet-software such as Excel or hand calculations and analyze the dataset with basic statistics.**	Cues, Questions, and Advance organizers Non-linguistic representations	R/R Quadrant D Creativity, Collaboration, Communication, Critical Thinking

UNIT RESOURCES

Vocabulary:

Biosphere- all life on Earth and all parts of the Earth in which life exists, including, land, water and the atmosphere.
Ecology- the scientific study of interactions among organisms and between organisms and their physical environment.
Biotic factor- any living part of the environment with which an organism might interact, including animals, plants, mushrooms and bacteria.
Abiotic factor- any nonliving part of the environment, such as sunlight, heat, precipitation, humidity, wind or water currents, soil type and so on.
Autotroph -organisms that can capture energy from sunlight or chemicals and convert it into forms that living cells can use.
Primary producer- An autotroph that stores energy in forms that make it available to other organisms that eat them.
Photosynthesis- the process used by plants and other autotrophs to capture light energy and use it to power chemical reactions at convert carbon dioxide and water into oxygen and energy rich carbohydrates such as sugars and starches.
Chemosynthesis- the process by which chemical energy is used to produce carbohydrates.
Heterotroph- organism that obtains food by consuming other living things; also called a consumer
Consumer -organism that relies on other organisms for its energy and food supply; also called a heterotroph
Food chain- series of steps in an ecosystem in which organisms transfer energy by eating and being eaten
Phytoplankton- photosynthetic algae found near the surface of the ocean
Food web-network of complex interactions formed by the feeding relationships among the various organisms in an ecosystem.
Zooplankton- small free floating animals that form part of the plankton.
Trophic level- each step in a food chain for food web
Ecological pyramid- illustration of the relative amounts of energy or matter contained within each trophic level in a given food chain or food web
Biomass- the total amount of living tissue within a given trophic level
Biochemical cycle- process in which elements, chemical compounds, and other forms of matter are passed from one organism to another and from one part of the biosphere to another
Nutrients- chemical substance organisms need to sustain life

Unit 6: Human Impacts

Content Area: Science	Course:Biology	UNIT: Human Impacts

Unit Description:	Unit Timeline:
The Human Impact Unit is intended to be an opportunity for students to show what they have learned throughout the year by applying their knowledge to solve a problem.Students will use the process of engineering design to identify a problem related to threatened or endangered species, or to genetic variation of organisms for multiple species and design a solution that would minimize human impacts on this problem.	3 weeks

DESIRED Results

Transfer Goal - ***Students will be able to independently use their learning to……***

1. Ask questions and define problems.
2. Develop and use models.
3. Plan and carry out investigations
4. Analyze and interpret data.
5. Use mathematical and computational thinking.
6. Construct explanations and design solutions
7. Engage in an argument from evidence.
8. Obtain, evaluate, and communicate information.

Understandings (Cross Cutting Concepts) – *Students will understand… (Big Ideas)*

1. Patterns
2. Cause and Effect
3. Scale, Proportion, & Quantity
4. Systems & System Models
5. Energy and Matter
6. Structure and Function
7. Stability and Change

Essential Questions: ***Students will keep considering…***

- Why is biodiversity a vital resource that should be protected?
- How do human behaviors cause a threat to biodiversity and what can be done to prevent this?
- How does the diversity of a system affect its health?
- How are human and natural systems interrelated?
- In what ways do we depend on natural systems?
- How do humans have an impact on the diversity and the stability of ecosystems?
- How do matter and energy link organisms to each other and their environments?
- How can change in one part of an ecosystem affect change in other parts of an ecosystem?

Human impacts could include things like Urban Sprawl

Standards Addressed
Students who demonstrate understanding can: ● HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.] Linked to MLS 9-12-LS2-C5 ● HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.] Linked to MLS 9-12-LS2-C6 ● HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

- HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.] Linked to MLS 9-12-LS2-C6
- HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.] Linked to MLS 9-12-LS4-C7

Disciplinary Core Ideas **Students will know...**	**Cross Cutting Concepts** **Students will understand….**	**Science and Engineering Practice** **Students will be able to...**
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-LS2-6)	Stability and Change Students understand the relationship between degree of change and stability in ecosystems, and the utility of the reasoning in supporting the explanation of how: 1. Modest biological or physical disturbances in an ecosystem result in maintenance of relatively consistent numbers and types of organisms. 2. Extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability, and can even result in a new ecosystem.	Engage in an argument from evidence. Students identify the given explanation that is supported by the claims, evidence, and reasoning to be evaluated, and which includes the following idea: 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. From the given materials, students identify: 1. The given claims to be evaluated 2. The given evidence to be evaluated 3. The given reasoning to be evaluated Students identify and describe additional evidence (in the form of data, information, or other appropriate forms) that was not provided but is relevant to the explanation and to evaluating the given claims, evidence, and reasoning: 1. The factors that affect biodiversity; 2. The relationships between species and the physical environment in an ecosystem; and 3. Changes in the numbers of species and organisms in an ecosystem that has been subject to a modest or extreme change in ecosystem conditions. Students describe the strengths and weaknesses of the

		given claim in accurately explaining a particular response of biodiversity to a changing condition, based on an understanding of the factors that affect biodiversity and the relationships between species and the physical environment in an ecosystem. Students use their additional evidence to assess the validity and reliability of the given evidence and its ability to support the argument that resiliency of an ecosystem is subject to the degree of change in the biological and physical environment of an ecosystem.
LS2.C: Ecosystem Dynamics, Functioning, and Resilience 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) LS4.D: Biodiversity and Humans Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary) (HS-LS2-7) LS4.D: Biodiversity and Humans 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,	Stability and change Students understand the negative effects of human activities on the environment and biodiversity. Examples include but are not limited to: 1. Overpopulation; 2. Overexploitation; 3. Habitat destruction; 4. Pollution; 5. Introduction of invasive species; and 6. Changes in climate. Students understand that proposed solutions to these human activities will impact overall environmental stability and changes.	Constructing Explanations and Designing Solutions Students design a solution that involves reducing the negative effects of human activities on the environment and biodiversity, and that relies on scientific knowledge of the factors affecting changes and stability in biodiversity. Examples of factors include but are not limited to: 1. Overpopulation; 2. Overexploitation; 3. Habitat destruction; 4. Pollution; 5. Introduction of invasive species; and 6. Changes in climate. Students describe the ways the proposed solution decreases the negative effects of human activity on the environment and biodiversity. Students describe and quantify (when appropriate) the criteria (amount of reduction of impacts and human activities to be mitigated) and constraints (for example, cost, human needs, and environmental impacts) for the solution to the problem, along with the tradeoffs in the solution.

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) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)		Students evaluate the proposed solution for its impact on overall environmental stability and changes. Students evaluate the cost, safety, and reliability, as well as social, cultural, and environmental impacts, of the proposed solution for a select human activity that is harmful to an ecosystem. Students refine the proposed solution by prioritizing the criteria and making tradeoffs as necessary to further reduce environmental impact and loss of biodiversity while addressing human needs.
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 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	Cause and Effect Students have an understanding of the reliance of ecosystem function and productivity on biodiversity, and that take into account the constraints of cost, safety, and reliability as well as cultural, and environmental impacts.	Using Mathematics and Computational Thinking Students create or revise a simulation that: 1. Models effects of human activity (e.g., overpopulation, overexploitation, adverse habitat alterations, pollution, invasive species, changes in climate) on a threatened or endangered species or to the genetic variation within a species; and 2. Provides quantitative information about the effect of the solutions on threatened or endangered species. Students describe the components that are modeled by the computational simulation, including human activity (e.g., overpopulation, overexploitation, adverse habitat alterations, pollution, invasive species, changes in climate) and the factors that affect biodiversity. Students describe the variables that can be changed by the user to evaluate the proposed solutions, tradeoffs, or other decisions. Students use logical and realistic inputs for the simulation that show an understanding of the reliance of 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-LS4-6)		function and productivity on biodiversity, and that take into account the constraints of cost, safety, and reliability as well as cultural, and environmental impacts. Students use the simulation to identify possible negative consequences of solutions that would outweigh their benefits Students compare the simulation results to expected results. Students analyze the simulation results to determine whether the simulation provides sufficient information to evaluate the solution. Students identify the simulations limitations. Students interpret the simulation results, and predict the effects of the specific design solutions on biodiversity based on the interpretation. Students revise the simulation as needed to provide sufficient information to evaluate the solution.
ESS2.D: Weather and Climate Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-7) ESS2.E Biogeology The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it.(HS-ESS2-7)	Stability and Change Students will understand how the evolution of photosynthetic organisms led to a drastic change in Earth's atmosphere and oceans in which the free oxygen produced caused worldwide deposition of iron oxide formations, increased weathering due to an oxidizing atmosphere and the evolution of animal life that depends on oxygen for respiration	Engaging in an Argument from Evidence Students develop a claim, which includes the following idea: that there is simultaneous coevolution of Earth's systems and life on Earth. This claim is supported by generalizing from multiple sources of evidence. Students identify and describe evidence supporting the claim, including: 1. Scientific explanations about the composition of Earth's atmosphere shortly after its formation; 2. Current atmospheric composition; 3. Evidence for the emergence of photosynthetic

	Students will also understand the causal links and feedback mechanisms between changes in the biosphere and changes in Earth's other systems	organisms; 4. Evidence for the effect of the presence of free oxygen on evolution and processes in other Earth systems; 5. In the context of the selected example(s), other evidence that changes in the biosphere affect other Earth systems. Students evaluate the evidence and include the following in their evaluation: 1. A statement regarding how variation or uncertainty in the data (e.g., limitations, low signal-to-noise ratio, collection bias, etc.) may affect the usefulness of the data as sources of evidence; and 2. The ability of the data to be used to determine causal or correlational effects between changes in the biosphere and changes in Earth's other systems. Students use at least two examples to construct oral and written logical arguments. The examples: 1. Include that the evolution of photosynthetic organisms led to a drastic change in Earth's atmosphere and oceans in which the free oxygen produced caused worldwide deposition of iron oxide formations, increased weathering due to an oxidizing atmosphere and the evolution of animal life that depends on oxygen for respiration; and 2. Identify causal links and feedback mechanisms between changes in the biosphere and changes in Earth's other systems
ESS3.C: Human Impacts on Earth Systems Scientists and engineers can make major contributions by developing technologies that produce	Stability and Change The Influence of Science, Engineering, and Technology on Society and the	Construct Explanations and Design Solutions Students use scientific information to generate a number of possible refinements to a given technological solution. Students:

less pollution and waste and that preclude ecosystem degradation.(HS-ESS3-4) ETS1.B: Developing Possible Solutions When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)(HS-ESS3-4)	Natural World	1. Describe the system being impacted and how the human activity is affecting that system; 2. Identify the scientific knowledge and reasoning on which the solution is based; 3. Describe how the technological solution functions and may be stabilizing or destabilizing the natural system; 4. Refine a given technological solution that reduces human impacts on natural systems; and 5. Describe that the solution being refined comes from scientists and engineers in the real world who develop technologies to solve problems of environmental degradation. Students describe and quantify (when appropriate): 1. Criteria and constraints for the solution to the problem 2. The tradeoffs in the solution, considering priorities and other kinds of research-driven tradeoffs in explaining why this particular solution is or is not needed. In their evaluation, students describe how the refinement will improve the solution to increase benefits and/or decrease costs or risks to people and the environment. Students evaluate the proposed refinements for: 1. Their effects on the overall stability of and changes in natural systems 2. Cost, safety, aesthetics, and reliability, as well as cultural and environmental impacts.
ISTE 3a	plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.	
ISTE 3b	evaluate the accuracy, perspective, credibility and relevance of information, media, data or other resources.	

ISTE 3c	curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
ISTE 3d	build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
ISTE 4a	know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
ISTE 4b	select and use digital tools to plan and manage a design process that considers design constraints and calculated risks.
ISTE 4c	develop, test and refine prototypes as part of a cyclical design process.
ISTE 4d	exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.
ISTE 6a	choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.
ISTE 6c	communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

Unit 6: Assessment

EVIDENCE of LEARNING			
Understanding 2-Cause and Effect 7-Stability and change	Standards HS-LS2-6 **HS-LS2-7** HS-LS4-6 **HS-ESS3-4** HS-ESS2-7 1- Ask questions and define problems. 4-Analyze and interpret data 6- Construct explanations and design solutions 7- Engage in an argument from evidence 8- Obtain, evaluate, and communicate information ISTE 3a, b, c, d ISTE 4a, b, c, d ISTE 6a, c	**Unit Performance Assessment**: **Description of Performance Task:** Students will use the process of engineering design to complete the Human Impact Project Students will identify a problem related the negative effects of human activities on the environment and biodiversity or threatened/endangered species, or to genetic variation of organisms for multiple species and design a solution that would minimize human impacts on this problem. Students will also design a plan to monitor the effectiveness of the proposed solution Engineering Process: a. Define the problem and resources available b. Brainstorm solutions c. Develop a plan d. Test your plan e. Improve the plan f. Analyze the plan and use it Possible ideas(but not limited to): Overpopulation, Overexploitation, Habitat destruction, Pollution, Introduction of invasive species, and Changes in climate. Students research a problem and design a solution as well as a strategy to monitor the solution and minimize human impact on the environment in reference to the identified problems. a. Allow students to define a problem and conduct research on this problem related to threatened or endangered species, or to genetic variation of organisms: 1. What is the problem? How have others approached it? 2. What are your constraints? 3. Prompt the students with questions that relate to defining the problem. a. Once they have identified a problem, students should do additional research on the topic they choose. They should evaluate their sources to be reliable	**R/R Quadrant** **21 Century** C 4C- critical thinking communication

		sources. b. In groups or individually, ask students to brainstorm and research solutions: 1. What are some possible solutions? Brainstorm ideas. Choose the best one. 2. What are some solutions that have already been researched? 3. What are constraints to the solutions suggested? c. Develop a plan: 1. Draw a diagram or write out your plan. Make lists of materials you will need. 2. Give students the opportunity to develop a plan. Be sure they create a template for collecting data to monitor the effectiveness of the solution. But they should know that their solution can be adjusted and revised depending on their data collection. d. Test your plan: During this step, allow students to share their designs with each other and provide feedback and suggestions. 1. Share your problem, the research, the solution, and plan to monitor with two peers. Peers should provide feedback about the solution presented. 2. Discuss ways of testing their design. This might include sharing the design/plan with classmates and getting suggestions. e. Improve the plan: 1. What concerns or questions did your peers have? Modify your plan to make it better. 2. Share your revised plan with another peer and get feedback on the modified plan. f. Analyze the plan and use it: 1. Ask students to write up a description for their plan that includes some reasons why they think it is important. Students will use the Design Project Guide to record the steps of their design process. Students create a presentation (google slides, PowerPoint, Prezi, etc.) detailing their design process, why they choose this problem, why it is a problem, why it needs to be solved, and how they would monitor its effect. Students **Teacher will assess:** 1. The student's attention to detail in following the design process. 2. The student's content understanding in what causes the problem. 3. The student's reflection on their design effectiveness and the method for monitoring the effectiveness.	

		<u>Performance:</u> **Mastery:** *Students will show that they really understand when they…* 1. Identify the causes of one problem and provide credible research to support the problem. 2. Design a solution to address the problem 3. Revise their design based on feedback 4. Develop a method to monitor the effectiveness of the design **Scoring Guide:** **Engineering Design Project Rubric**	

Unit 6: Sample Activities

SAMPLE LEARNING PLAN				
Understanding	**Standards**	**Major Learning Activities:**	**Instructional Strategy Category:**	**R/R Quadrant: 21C:**
Structure and Function	HS-LS4-6 Construct Explanations and Designing Solutions ISTE Standard addressed	**Lesson**:Farming for Ecosystem Services **Objective**: ● Students will know "ecosystem services" and the differences between supporting, provisioning, regulating, and cultural services. ● Students will understand the biodiversity ecosystem function hypothesis. ● Students will be able to justify decision-making in a farming simulation as decisions relate to economic and ecological factors. **Activity:** Using a lesson from the Biengergy Sustainability Project, students will explore the relationship between biodiversity and ecosystem services, from basic ecological theory to their economic value. Provided with a short introduction to the types of ecosystem services and their importance, students will play a game where they must make decisions regarding how to invest a limited amount of money on their own for-profit farm—can they manage economic and ecological tradeoffs to design a productive farm that also enhances ecosystem services? Materials needed: ● Introductory powerpoint slides (available on "Farming for Ecosystem Services" lesson page on the KBS GK-12 website) ● "Croptions" game materials (all are available online for printing, except calculators) o Calculators o Blank game boards (farm template, 2 per student- begin with 1)* o Score cards (1 per student, score cards are for two years) o Croptions Menus o Game pieces (crop squares, buffer strips, bee hives)**	Non-linguistic representations Cooperative Learning Identifying Similarities and Differences Generating and Testing Hypotheses	In which quadrant does this activity fall on the Rigor / Relevance framework? A, B, C, D? Creativity, Collaboration, Communication, Critical Thinking

		Begin by assigning each student one game board (farm template) to work with. If students have money to use after the first round of the game (Year 1), a second game board can be provided to "expand" their farm. This game is designed to be played for two rounds (years), so if students write on their game board, they will need a new copy for the second year of the game. 1. Introductory material slides presentation (refer to lesson plan "Background" and notes provided in PowerPoint file for further information) 2. Instruction for "Croptions" decision-making game (detailed instructions and example illustrations are provided in the introductory slides file. There are additional slides at the end of the PowerPoint for use DURING the game, depending on which game cards are drawn) In this game, students will design a profitable farm. They will begin with a parcel of land that is currently a wood lot and they will plant six crops. Their goal is to grow food while protecting the ecosystem services. The person with the most money at the end wins the game. 3. "Croptions" decision-making game (Years 1 and 2) 4. Using the cooperative learning gallery walk structure upon conclusion of game, students display their farm designs and score cards. Then, students walk around the classroom to view the farms that their classmates created as well as their profits. 5. Follow-up Discussion (guiding questions are provided in the PowerPoint slides) Lesson Plan Introductory slides PDF Costanza 1997 Nature – PDF (Teacher resource for background reading) *"Croptions" Game Materials* Student Game Board PDF Student Croptions Menu PDF Student Score Card PDF		

		Teacher – Game Board and Pieces to PRINT – PDF Teacher – Game Board and Pieces to EDIT – PPT Teacher – Menu and Scorecard Spreadsheet to EDIT – EXCEL Teacher Resource – Costs for Climate and Pest-Disease Cards – DOC **Check for understanding:** Exit Card: Why is it difficult for farmers to protect all ecosystem services?		
Cross Cutting Concept Addressed: Structure and function	HS-ESS3-4 6. Constructing explanations (for science) and designing solutions for engineering 8. Obtaining, evaluating, and communicating information ISTE Standard addressed: 4.a and 6.c	**Lesson**: Design an Environmentally Friendly Home **Objective**: ● Students will know friendly building design by applying material conservation, energy conservation, water conservation concepts to design their own environmentally friendly home. ● Students will be able to justify decision-making in a home building simulation as decisions relate to economic and ecological factors. **Activity:** For this project students will research environmentally friendly building designs to designing a home. 4 primary areas of research/design will include: building materials (material conservation), energy conservation, water conservation, and at least one other idea to incorporate into the home that do not fit into the other 3 categories. Students will turn in a diagram (blueprint) of the home depicting the conservation efforts and also a written summary that explains how the designed home and the benefits of each of your conservation efforts are effective. Along with the written summary, students will also have a price sheet detailing cost to build the environmentally friendly home. The results of the group research will present their findings to the class. **Check for understanding:** In class presentation will be scored. lesson and scoring rubric	Setting Objectives and providing feedback Reinforcing Effort and Providing recognition cooperative learning Cues, Questions, and Advance organizers Non-linguistic representations Summarizing and note taking Identifying Similarities and Differences	Rigor / Relevance C Creativity, Collaboration, Communication, Critical Thinking

Cross Cutting Concept Addressed: Cause and Effect	NGSS Code: HS-LS2-7 SEP Addressed: Constructing explanations (for science) and designing solutions (for engineering) ISTE Standard addressed: 4.a and 6.c	**Lesson**: Save the Ecosystems! **Objective**: ● Students will know a local, state or national environmental threat. ● Students will be able to justify decision-making involved with devising a plan to mitigate the environmental problem they discover. **Activity:** The role biodiversity plays in an ecosystem is an important component of understanding ecology. This project will help students to understand the role individual species (including humans) play within a specific ecosystem. Students will develop a plan: First, research (using credible sources) an environmental threat that is occurring currently on the local, state or national level. Secondly, develop a plan to clean up the specific threat to the ecosystem. The plan will be presented to the class. See your scoring rubric and specific directions for more details. **Check for understanding:** In class presentation will be scored. Save the Ecosystems! activity	cooperative learning Summarizing and note taking	Rigor / Relevance D Creativity, Collaboration, Communication, Critical Thinking
Cross Cutting Concept Addressed: Cause and Effect	NGSS Code: HS-LS2-6 SEP Addressed: Engaging in argument from evidence ISTE Standard addressed:	**Lesson**: Crayfish Habitat Lab **Objective**: ● Students will determine the effect of habitat loss on crayfish aggressive behavior. ● Students will be able to justify a plan to remediate the loss of habitat in their local environment. **Activity:** In this activity students will test the aggressive behavior of crawfish by manipulating the number of hiding places (small flower pot or tube) in an artificial habitat. Four crawfish are given four hiding boxes and observed for a predetermined amount of time to establish hiding box chicce. Then the crawfish are removed as well as one hiding habitat. The crawfish are reintroduced and observed with the number of aggressive behaviors noted and	Generating and Testing Hypotheses	Rigor / Relevance framework: C Critical Thinking

	5.b	counted. Another hiding place is removed and trials repeated to note the characteristics of the behaviors of the crawfish. **Check for understanding:** On an exit ticket explain how ecosystem changes affect crawfish survivorship. Crayfish lab		
Stability and Change	NGSS Code: HS-LS2-6 SEP Addressed: Engaging in argument from evidence ISTE Standard addressed: 3b,3c,3d NGSS Code: HS-LS2-7 SEP Addressed: Constructing explanations (for science) and designing	**Lesson: Responding to a Changing Climate** Objectives: ● Understand the following plant responses to climate change: *elevational range shifts* (attrition and community shifts); *phenological shifts* (over extended time periods); *community shifts* (novel competition and species response); and *changes in biodiversity* (resistance and resilience). ● Assess how specific vernal pool plant communities have responded to fluctuations in annual weather patterns. ● Predict how specific vernal pool plant communities may respond to future climate events. **Activity:** This case study uses a jigsaw activity to introduce students to four specific plant responses to climate change: elevational range shifts, phenology shifts, community shifts, and changes in biodiversity. Students become "experts" on one of these responses by reading an article (from *Nature, Science,* or *American Journal of Botany*; not included with the case) on their assigned topic and then sharing their expertise with others in class. In order to hone their understanding and increase retention on these topics, students then learn about plant communities found in a specific system—vernal pools or seasonal wetlands typical of Mediterranean climates (a PowerPoint	Summarizing and Note taking Cooperative Learning	Rigor / Relevance framework: C Critical Thinking

	solutions (for engineering)	presentation on this topic is included). Students accomplish several small group tasks to assess how different vernal pool plant communities have responded to fluctuations in annual weather patterns and predict how these communities may respond to greater weather variability resulting from future climatic change. Source: National Center for Case Study Teaching in Science http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=962&id=962 **Link to resources in Curriculum Document:** **https://drive.google.com/open?id=1vIEM5FqDz-FEA3GgetNPkQaCe2tCgMgn** **Check for Understanding:** Checklist for each Task to ensure students are making progress in their understanding. https://docs.google.com/document/d/1dhJyat5joVudGypjZWNN2xKZKxlhtZ2_QvBsaiGFnCQ/edit?usp=sharing		

Unit 6: Resources

UNIT RESOURCES
Teacher Resources: ● "Planet Earth II" video series has human impact in every episode ● Bill Nye "Stuff Happens" series ● "Life After People" Video series

Vocabulary:

Urban sprawl or **suburban sprawl** expansion of human populations away from cities into low-density, and usually car-dependent suburb communities.

anthropogenic (human) impact changes to biosphere, ecosystems, biodiversity, and natural resources caused directly or indirectly by humans