Course of Study-The Living Earth

Overview:

Title of Course: The Living Earth	
Course Author(s): **John Hayden, Jessica Skieresz, Alyssa Sandner**	Schools where the course will be taught: **Tamalpais High School, Sir Francis Drake High School, Redwood High School, Tamiscal and San Andreas**
Length of Course: **1 year**	Subject Area and Discipline: **Life Science/Earth Science**
Grade Levels: **10th**	Is this course an integrated course? **Yes**
Is this course being submitted for possible UC honors designation? **No**	Are you seeking UC approval? If so, in what area (A-G)? **Yes, D**
Prerequisites (required or recommended):	Co-requisites (required or recommended):
Check all that apply: ❑ UC A-G course X ❑ Graduation Requirement X ❑ Elective ❑ Honors/AP ❑ ROP Board approved: 2/12/19 UC Approved: 2/26/19	

Introduction

Course Overview:

The Living Earth is a course built upon performance expectations (PEs) that blend the disciplinary core ideas (DCIs) of biology and earth science with scientific and engineering practices (SEPs) and crosscutting concepts (CCCs). This 3 dimensional approach supports students in developing scientific knowledge and the skills of scientists and engineers. By using in depth phenomena central to these fields of science, students develop an understanding of the core ideas related to Ecosystem Interactions and Energy, Photosynthesis and Respiration, Evidence of Evolution, Inheritance of Traits, Structure, Function and Growth from Cells to Organisms, and Ecosystem Stability and Response to Climate Change. The performance expectations focus on several scientific practices including: developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations which students use to demonstrate understanding of the core ideas. Students are expected to demonstrate understanding of several

engineering practices, including design and evaluation as well as to develop an understanding of the cross cutting concepts central to the nature of science.

Unit 1: Ecosystem Interaction and Energy

Stage 1 Desired Results

ESTABLISHED LEARNING GOALS **(PEs)**

HS-LS2-1 - Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
HS-LS2-2 - Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
HS-LS2-4 - Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
HS-LS2-8- Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.
HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth

Transfer

Students will evaluate the impact of a human activity (e.g. pollution, habitat destruction, overfishing) on the SF Bay ecosystem and analyze of mitigation or adaptation strategies designed to minimize negative consequences for humans and the environment.

Meaning Making

UNDERSTANDINGS **(CCCs)**

Students will understand that...

- Mathematical and computer models can be used to simulate systems and interactions—including energy, and matter flows—within and between systems at different scales.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. Students will model energy flow through an ecosystem in a variety of activities.
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be

ESSENTIAL QUESTIONS

1. What is the carrying capacity of a population?

2. How does energy flow in the San Francisco Bay?

3. How does matter cycle in the San Francisco Bay Area?

4. How has biodiversity in the SF bay changed over time?

5. How does group behavior aid survival in the San Francisco Bay ecosystem?

6. How does human activity affect the San Francisco Bay ecosystem?

<table>
<tr><td rowspan="4">materials and surface processes.
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-ESS3-6 - Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.</td><td>suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.</td><td></td></tr>
<tr><td colspan="2">Acquisition</td></tr>
<tr><td>Students will know... (DCIs)

● Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support.
● 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. Given this inefficiency, there are generally fewer organisms at higher levels of a food web.
● A complex set of interactions within an ecosystem affect organism stability. Biological or physical disturbances also affect organisms and can challenge and ecosystem in terms of resources and habitat availability.
● Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.</td><td>Students will be skilled at... (SEPs)

● Students make claims about energy available at different trophic levels using the 10% rule. They can explain how the rule is governed by the laws of thermodynamics. They can describe how the rule limits the size of the different trophic levels and the trophic structure overall. Students can use data sets to evaluate whether the 10% rule is accurate.
● When given a data set, students make scatter plots showing population size over time. They use their graphs to identify population growth as either following an exponential or logistic pattern. Students use such graphs to show how changes in limiting factors may change population growth in the future.
● Students explain how they will know whether their proposed mitigation strategy is effective by engaging in argument from evidence.</td></tr>
<tr><td colspan="3">Unit Summary:
In an ecosystem nutrients cycle between organisms and their environment and energy is transferred with a loss of efficiency. This creates specific feeding and behavioral relationships between organisms such as: trophic levels and food web interactions. This can affect population</td></tr>
</table>

size and changes within a population. The growth of populations in ecosystems is affected by both density-dependent and density-independent limiting factors. Within populations, individuals will often work together to minimize the impact of such factors. Population fluctuations due to changes in the limiting factors can affect the biodiversity of an ecosystem. Human activities can also significantly affect the biodiversity of an ecosystem. Ongoing research and investigation provides scientific understanding of how human impacts influence ecosystem health, and how humans may choose to offset or prevent risks associated with our activities. Students will use available research and understanding to explore human impacts on the San Francisco Bay. As part of their work, students will evaluate solutions for mitigating human impacts associated with a given activity to further demonstrate understanding of ecosystem dynamics and environmental health.

Stage 2 - Evidence	
Learning Goals Measured: HS-ESS3-6 - Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.	**Success Criteria** (e.g.. Learning progression, rubric, proficiency scale, etc.) HS-ESS3-6
	Sample Assessment: Students will evaluate mitigation and adaptation solutions for the delta smelt by identifying four proposed solutions for saving the delta smelt from extinction. They will list the pros and cons of each solution in terms of ecological and estimated economic value. They will compose a Claim-Evidence-Reasoning argument to conclude how effective the mitigation and adaptation efforts have been to save the delta smelt.
Stage 3 – Learning Plan	
Learning Goals Addressed: LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS2.A: Interdependent Relationships in Ecosystems LS2.B: Cycles of Matter and Energy Transfer in	**Sample Assignment:** Participate in a jigsaw reading of the paper *Biology and Population Dynamics of Sacramento Splittail (Pogonichthys macrolepidotus) in the San Francisco Estuary: A Review.* San Francisco Estuary and Watershed Science. 2004. As students read their portion of the paper, they should look for answers to the questions - (1) *How have drought, salinity changes, invasive species, and humans affected the Sacramento Splittail in the San Francisco Bay?* (2) *How are changes in the Sacramento Splittail population likely to affect biodiversity in the San Francisco Bay?* Students should track their answers in a journal or Google Doc.
	Sample Lab: Pea Soup Pond

Ecosystems SEP: Using Mathematics and Computational Thinking SEP: Obtaining, Evaluating, and Communicating Information CCC: Cause and Effect	In this laboratory activity, students learn how water can be polluted by algal blooms. They grow algae with different concentrations of fertilizer or nutrients and analyze their results as environmental engineers working to protect a local water resource. They make connections between algae growth, fertilizers and stream habitats. **Differentiated Approaches:** Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended). If students are struggling to understand/access the Sacramento Splittail paper, they could read an alternative article related to population dynamics from the website Newsela. Newsela allows users to quickly alter the reading level of many articles. For example, see the article Burgeoning bear populations bring up conservation debate. Additionally, we highly recommend teachers vary instructional strategies according to the needs of their students. Many students, including English learners and special education students, will benefit from the use pre-reading activities, graphic organizers, small group discussion scaffolds, flexible assignment due dates, and competency-based assessment. Advanced students could be encouraged to explore population dynamics and related issues in species other than those presented in this lesson sequence. For example, see How Warp-Speed Evolution is Transforming Ecology. Scientific American. 2018.

Unit 2: Carbon's Role in the Living Earth		
Stage 1 Desired Results		
ESTABLISHED LEARNING GOALS **(PEs)** HS-LS1-5 - Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. HS-LS1-6 - Construct and revise an explanation	***Transfer***	
	Students will use their understanding of forests and their influence on atmospheric gas and climate regulation to model and explain how oceans and/or soils also regulate the atmosphere and climate.	
	Meaning Making	
	UNDERSTANDINGS **(CCCs)** *Students will understand that…*	ESSENTIAL QUESTIONS

based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. HS-LS1-7 - Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. HS-LS2-3 - Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. HS-LS2-5 - Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. HS-ESS3-4 - Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. HS-ESS3-6 - Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.	• Students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. • Much of science deals with constructing explanations of how things change and how they remain stable. • Systems can be designed for greater or lesser stability. • Feedback (negative or positive) can stabilize or destabilize a system. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	1. Where is carbon stored on Earth? 2. Why are carbon sinks important? 3. How does deforestation affect carbon sinks? 4. How are photosynthesis and cellular respiration connected?
	Acquisition	
	Students will know… **(DCIs)** • 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) • As matter and energy flow	*Students will be skilled at…* **(SEPs)** • Construct drawings or diagrams as representations of events or systems—for example, draw a picture of an insect with labeled features, represent what happens to the water in a puddle as it is warmed by

	through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6) ● The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HS-LS1-6) ● As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7) ● Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3) ● Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is	the sun, or represent a simple physical model of a real-world object and use it as the basis of an explanation or to make predictions about how the system will behave in specified circumstances. ● Represent and explain phenomena with multiple types of models—for example, represent molecules with 3-D models or with bond diagrams—and move flexibly between model types when different ones are most useful for different purposes. ● Construct their own explanations of phenomena using their knowledge of accepted scientific theory and linking it to models and evidence. ● Use primary or secondary scientific evidence and models to support or refute an explanatory account of a phenomenon.

	exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5) ● The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary to HS-LS2-5) ● The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to (HS-ESS2-5) ● Resource availability has guided the development of human society. (HS-ESS3-1) ● Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1) (HS-ESS3-1) ● Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4) ● When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider	

	social, cultural and environmental impacts.*(secondary to HS-ESS3-4)*	

Unit Summary:
Photosynthesis, cellular respiration, carbon cycling and human activity all influence the quality and availability of carbon sinks on the planet. Plants capture sunlight and convert CO_2 into sugars, storing a good portion of Earth's carbon in the biomass of plants. While organisms respire and humans burn fossil fuels releasing CO_2 back into the atmosphere. This release of energy allows organisms to fuel their bodies by harnessing ATP at the cellular level, and on a larger scale allows humans to fuel their lifestyles by combusting fossil fuels for transportation, industry and electricity. This relationship between photosynthesis and cellular respiration provides a fuller picture of how carbon is cycled and its impact on atmospheric gas and climate regulation. Forests, oceans and soils all have profound effects on carbon cycling and the structure of carbon sinks on Earth. Students will apply their understanding of photosynthesis and respiration to model how forests, oceans and/soil act as as major aspects of the carbon cycle and to explain their understanding of the value and importance of carbon sinks for regulating atmospheric gases and climate.

Stage 2 - Evidence

Learning Goals Measured:
**can be referenced by number*

HS-ESS3-4 - Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
HS-ESS3-6 - Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Success Criteria (e.g.. Learning progression, rubric, proficiency scale, etc.)

HS-ESS3-4
HS-ESS3-6

Sample Assessment
Students will construct an explanation for how carbon cycling and storage in forests, oceans and/or soils provide carbon sinks. Students will elaborate to include the importance of carbon sinks for atmospheric gas and climate regulation.

Stage 3 – Learning Plan

Learning Goals Addressed:

Sample Assignment:

LS1.C: Organization for Matter and Energy Flow in Organisms LS2.B: Cycles of Matter and Energy Transfer in Ecosystems LS2.B: Cycles of Matter and Energy Transfer in Ecosystems PS3.D: Energy in Chemical Processes and Everyday Life SEP: Developing and Using Models SEP: Constructing Explanations CCC: Energy and Matter	Students will participate in the kinesthetic activity Modeling Photosynthesis. This will help them better understand how carbon is used by plants. **Sample Lab:** Students will conduct an investigation to measure yeast respiration under varied conditions. Students will collect and analyze data to explain the relationship between percent concentration of food and CO_2 generated in a closed environment. **Differentiated Approaches:** We highly recommend teachers vary instructional strategies according to the needs of their students. Many students, including English learners and special education students, will benefit from the use pre-reading activities, graphic organizers, small group discussion scaffolds, flexible assignment due dates, and competency-based assessment. In the context of the sample assignment, it will be important to carefully chunk the activity so that it is accessible to all learners. English language learners should be partnered with fluent speakers to aid vocabulary development and understanding. Teachers should physically model the activity for students who are struggling to read/understand the instructions. Advanced students could be encouraged to investigate the specific biochemical pathways of photosynthesis and cellular respiration. They could also evaluate different variations of photosynthesis that exist such as C3, C4, and CAM.

Unit 3: Evidence for Evolution		
Stage 1 Desired Results		
ESTABLISHED LEARNING GOALS **(PEs)** HS-LS4-1-Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence HS-LS4-2-Construct an explanation based on	***Transfer***	
	Students will create an infographic that shows and justifies the evolutionary relationships between *H. sapiens, H. erectus, H. habilis, and H. neanderthalensis*.	
	Meaning Making	
	UNDERSTANDINGS **(CCCs)** *Students will understand that…*	ESSENTIAL QUESTIONS

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<tr>
<td rowspan="4">evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and</td>
<td>● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
● Empirical evidence is needed to identify patterns.
● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</td>
<td>1.What are the mechanisms that drive evolution forward?

2.) What is the evidence for biological evolution?

3.) How have changes in Earth's structure influenced the evolution of living things?

4.) How are H. sapiens, H. erectus, H. habilis, and H. neanderthalensis related?</td>
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<tr>
<td colspan="2">Acquisition</td>
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<td>Students will know…(DCIs)

● Genetic information, like the fossil record, provides evidence of evolution.
● Natural selection occurs when there is (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information.
● 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, (3) competition for an environment's limited supply of the resources, and (4) proliferation of organisms that are better able to survive and reproduce.
● Natural selection leads to adaptation. Natural</td>
<td>Students will be skilled at…(SEPs)

● Students will communicate scientific information in multiple formats around the theory of evolution and support their claims with evidence.
● Students will defend the claim that Natural selection, genetic drift, and gene flow drive biological evolution forward.
● Students will construct an explanation using scientific information and data to show the connections between geological evolution and the impacts on biological evolution.</td>
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early history. HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.	selection is the differential survival and reproduction of organisms in a population that have an advantageous heritable trait. ● Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean. ● Objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. ● Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. ● Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. ● Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. These changes depend on the amounts of human-generated greenhouse gases added to the atmosphere and by the ways in which these gases are absorbed by the ocean	

	and biosphere. ● The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. ● Resource availability has guided the development of human society. ● Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. ● Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.	

Unit Summary:
Students investigate the process of natural selection by conducting simulations and collecting data. They then consider the role of genetic drift and gene flow in driving evolution forward. Students investigate the different lines of evidence for the theory of evolution, including hominid evolution. They consider the strengths and weaknesses of this evidence. Students investigate different lines of evidence for the theory of plate tectonics. They consider how island formation can lead to speciation events in lizards. Students then research additional relationships between the changing Earth and biological evolution. The unit culminates with a performance task where they describe the evolutionary story of *H. sapiens, H. erectus, H. habilis, and H. neanderthalensis.*

Stage 2 - Evidence

Learning Goals Measured: HS-ESS2-7 Construct an argument based on evidence about the	**Success Criteria:** The success criteria for the unit is the NGSS performance expectations. HS-ESS2-7

<table>
<tr><td>simultaneous coevolution of Earth's systems and life on Earth.</td><td>Sample Assessment:
Students will discuss various criticisms of Darwin's Theory of Evolution by Natural Selection. They will utilize what they have learned about the Darwin's theory to respond to 6 different arguments. The class will close when a whole class discussion takes place about the scientific community's response to these criticisms.</td></tr>
<tr><td colspan="2">Stage 3 – Learning Plan</td></tr>
<tr><td rowspan="3">Learning Goals Addressed:

LS4.B: Natural Selection
LS4.C: Adaptation

SEP: Engaging in Argument from Evidence

CCC:Cause and Effect</td><td>Sample Assignment:
Students will explore the evidence for plate tectonics using maps of tectonic plate boundaries, maps of earthquake occurrences, maps of rock ages in the sea floor, maps of volcano locations and fossil evidence. The will evaluate the patterns they observe and draw conclusions based on their findings.</td></tr>
<tr><td>Sample Lab:
Students will engage in an Insect Evolution Lab where they simulate natural selection in changing environments. Students collect data that can be used as evidence for natural selection.</td></tr>
<tr><td>Differentiated Approaches:
Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended).

We highly recommend teachers vary instructional strategies according to the needs of their students. Many students, including English learners and special education students, will benefit from the use pre-reading activities, graphic organizers, small group discussion scaffolds, flexible assignment due dates, and competency-based assessment.

In the context of the sample assignment, videos of seafloor spreading can be used to help visual learners. Definitions of basic vocabulary words (e.g. fault, paleomagnetism, hot spot) should be reviewed and confirmed prior to studying the maps.

Advanced students could be encouraged to research mechanisms beyond natural selection, genetic drift, and gene flow such as horizontal gene flow or epigenetics. To begin, students could listen to the Podcast from Radiolab titled Infective Heredity about horizontal gene flow.</td></tr>
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Unit 4: Genetics and Inheritance

Stage 1 Desired Results

ESTABLISHED LEARNING GOALS **(PEs)**

HS-LS3-1-Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
HS-LS3-2-Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
HS-LS3-3-Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
HS-LS4-2-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)

Transfer

Students will be able to independently use their learning to…
Students will provide a scientific explanation for gene editing technology and evaluate possible implications of using gene editing to modify a genome.

Meaning Making

UNDERSTANDINGS **(CCCs)**
Students will understand that…

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

ESSENTIAL QUESTIONS

1. How are traits inherited?

2. How does heredity influence diversity?

3. How has diversity influenced the survival of living things?

4. How do scientists use heredity and genetics to understand changes in living things over time?

Acquisition

Students will know… **(DCIs)**

- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. (secondary to HS-LS3-1) (Note: This Disciplinary Core Idea is also addressed by HS-LS1-1.)
- Each chromosome consists of a

Students will be skilled at… **(SEPs)**

- Ask questions that arise from examining models or a theory to clarify relationships.
- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and

competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment HS-LS4-3-Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. HS-ETS1-3-Evaluate a solution to a complex real-world problem with many constraints	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. ● In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. ● Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. ● 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	problems, using digital tools when feasible. ● Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS4-2)

	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. ● Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. ● Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. ● 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.	

Unit Summary:
In this unit on genetics and inheritance, students explore patterns of inheritance based on case studies of human genetic disorders with a focus on Duchenne's Muscular Dystrophy. Students then learn how diversity influences the survival of organisms as illustrated by their work with antibiotic resistance. Ultimately, students evaluate the costs and benefits of using biotechnology to sequence, diagnose and modify genes as a means of identifying and altering traits.

Stage 2 - Evidence

Learning Goals Measured:
**can be referenced by number*

HS-LS3-1-Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

HS-LS3-2-Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Success Criteria (e.g.. Learning progression, rubric, proficiency scale, etc.)

HS-LS3-1
HS-LS3-2

Sample Assessment:
Students will explain how someone acquires Duchenne Muscular Dystrophy. They will also draw a model to explain how the boys in the video they watched (and anyone with DMD) acquired it and how this relates to their physical symptoms. In addition, they will answer "Who is more likely to acquire DMD, boys or girls? Why is that? Could a person have a mutated gene for dystrophin but not have DMD? How?"

Stage 3 – Learning Plan

Learning Goals Addressed:
**can be referenced by number*

LS1.A: Structure and Function

LS3.A: Inheritance of

Sample Assignment:
Students will watch a video of bacterial growth and mathematically compute the rate of growth so that they can graphically model the rate. They will read an article and evaluate how antibiotics work which will lead to their exploration and understanding of antibiotic resistance.

Traits LS4.B: Natural Selection LS4.C: Adaptation SEP: Analyzing and Interpreting Data SEP: Constructing Explanations and Designing Solutions CCC: Cause and Effect CCC: Scale, Proportion, and Quantity	
	Sample Lab: Students will further their understanding of genetics and by conduct a Drosophila fruit fly lab investigation. The focus of the lab will be on using probability and statistics as evidence to support inheritance.
	Differentiated Approaches: Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended). Mathematical models can be constructed in pairs or as a class to support students who are struggling to construct models independently. Laboratory investigations can be differentiated for students to conduct single variable investigations with qualitative analysis. Additionally, we highly recommend teachers vary instructional strategies according to the needs of their students. Many students, including English learners and special education students, will benefit from the use pre-reading activities, graphic organizers, small group discussion scaffolds, flexible assignment due dates, and competency-based assessment. Advanced students can construct mathematical rules/equations that reflect their mathematical model. Advanced students can conduct multi-variable laboratory investigations with complex statistical analysis.

Unit 5: **Structure, Function and Growth (from Cells to Organisms)**	
Stage 1 Desired Results	
ESTABLISHED LEARNING GOALS **(PEs)** 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	***Transfer***
	Students will investigate relationships between choices made in adolescence and the ripple effects on human development. Students will develop a model to help them explain these consequences and determine methods for rectifying any residual disturbance to homeostasis.
	Meaning Making

<table>
<tr>
<td rowspan="4">specialized cells.
HS-LS1-2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
HS-LS1-3 - Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
HS-LS1-4 - Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.</td>
<td>UNDERSTANDINGS (CCCs)
Students will understand that…

● Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.
● Feedback (negative or positive) can stabilize or destabilize a system.</td>
<td>ESSENTIAL QUESTIONS

1. What is the structural hierarchy of organization in the body?

2. How do systems work in a multi-celled organism to maintain homeostasis and what happens if there is a change in the system?

3. How does the structure of DNA affect how cells look and behave in the teen body?

4. How does the teen brain grow and develop into adulthood?</td>
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<td colspan="2">Acquisition</td>
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<td>Students will know… (DCIs)

● Systems of specialized cells within organisms help them perform the essential functions of life.
● All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)
● Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.</td>
<td>Students will be skilled at…(SEPs)

● Use a model to provide mechanistic accounts of phenomena.
● Develop a complex model that allows for manipulation and testing of a proposed process or system.
● Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.
● Plan and conduct an investigation individually and collaboratively to produce data to serve as</td>
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	• 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. • 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.	the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-LS1-3

Unit Summary:
Students will examine how multicellular organisms develop from simple cells into complex multicellular organisms with a focus on the adolescent. They will explore cell division through mitosis, and learn about the importance of cellular differentiation. By looking at hierarchical organization such as in the adolescent brain, students will justify how the sum of the parts equals the whole. In order to maintain stable internal conditions, organisms regulate processes through

feedback mechanisms. After exploring the process of building proteins from genetic information, students will evaluate the health and wellness of adolescents when structures, growth and/or homeostasis is disrupted.

Stage 2 - Evidence	
Learning Goals Measured: **can be referenced by number* HS-LS1-2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-LS1-4 - Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.	**Success Criteria** (e.g.. Learning progression, rubric, proficiency scale, etc.) HS-LS1-2 HS-LS1-4 **Sample Assessment:** Students will explore the processes that make up and regulate our bodies. They will design working models along with a campaign for the best organ system and best organelle as a project. These models will be made from products found in the household and display the function and use of the organ system/organelle. Students will then perform an investigation of how homeostasis works in their own bodies and determine how factors like drug use, alcohol consumption, metabolic conditions, and weather disturb these homeostatic processes.
Stage 3 – Learning Plan	
Learning Goals Addressed: **can be referenced by number* LS1.A: Structure and Function LS1.B: Growth and Development of Organisms SEP: Developing and Using	**Sample Assignment:**. Just like elected officials help our country to run smoothly, the organ systems help us maintain homeostasis and the organelles in the cells of those systems help our bodies to carry out the functions that allow us to live. In this activity students campaign for a specific body system as *The Most Important System.* Students will also be campaigning for a "Vice President" which is *the Most Important Organelle* in the system. Additionally, students must identify an opponent organ system and defend their system. Students must design and develop functioning models using household products, create a slogan and make a campaign poster (or video). Through the slogan and poster students will provide a scientific argument, based on evidence that, without the organelle, the cell and the organism's homeostasis would collapse.

Models SEP: Planning and Carrying Out Investigations CCC: Structure and Function	
	Sample Lab: **"Homeostasis and exercise"** Homeostasis means maintaining a relatively constant state of the body's internal environment. The term used to describe a pattern of response to restore the body to normal stable level is termed negative feedback. When a stimulus (environment change) is met by a response that reverses (negates) the trend of the stimulus, it is negative feedback. As a result, the internal environment is returned to normal. A body's temperature, heart rate, and blood pressure need to remain within certain set ranges. In this lab, students will work in groups to examine the effects of exercise on the circulatory and respiratory systems, and on perspiration level. They will then observe how the body reacts when exercise is stopped. Then they apply knowledge to research how factors like drug use, alcohol consumption, metabolic conditions, and weather disturb these homeostatic processes.
	Differentiated Approaches: Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended). For students who are struggling with the accurate collection of data in the Homeostasis lab can utilize already provided data in strategic groupings. Additionally, we highly recommend teachers vary instructional strategies according to the needs of their students. Many students, including English learners and special education students, will benefit from the use pre-reading activities, graphic organizers, small group discussion scaffolds, flexible assignment due dates, and competency-based assessment. Advanced students can be further pushed by having to determine the disturbances in homeostasis in different scenarios as a medical doctor would.

Unit 6: **Ecosystem Stability and the Response to Climate Change**

Stage 1 Desired Results

<table>
<tr><td rowspan="8">ESTABLISHED LEARNING GOALS (PEs)

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.
HS-LS2-7 -Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-LS4-5 -Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
HS-LS4-6 -Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
HS-ESS3-5-Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…
Design and propose solutions to mitigate the impacts of climate change on the biosphere.</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS (CCCs)
Students will understand that…

● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
● When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.</td><td>ESSENTIAL QUESTIONS

1. What affects changes in ecosystems that ultimately affect populations?

2. What are the changes that are happening in the climate and what effects are those having on life?

3. How are human activities impacting Earth’s systems and how does that affect life on Earth?

4. What can humans do to mitigate their negative impact on the environment?</td></tr>
<tr><td colspan="2">Acquisition</td></tr>
<tr><td>Students will know… (DCIs)

● 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</td><td>Students will be skilled at…(SEPs)

● Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
● Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.</td></tr>
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impacts to Earth systems. HS-ESS3-6 -Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. HS-ETS1-1 - Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. HS-ETS1-2 - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. HS-ETS1-3 - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. HS-ETS1-4 - Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	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. ● Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). ● Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. ● 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. ● Changes in the physical environment, whether naturally occurring or human induced, have thus	● Analyze data using computational models in order to make valid and reliable scientific claims. ● Create or revise a simulation of a phenomenon, designed device, process, or system. ● Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

	contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. ● Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. ● Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. ● Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. ● Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	

	● Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. ● Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	

Unit Summary:
Students will evaluate effects of climate change and identify strategies for minimizing its impacts on natural and human systems. Students will explore various local impacts of climate change: flooding, wildfires, warmer temperatures, etc. By analyzing quantitative and qualitative evidence and interpreting models for climate change, students will develop an understanding of the impacts based on different scientific projections. Ultimately, students will examine criteria and constraints of various mitigating strategies for climate change and propose a solution they feel has the greatest potential for sustainability.

Stage 2 - Evidence

Learning Goals Measured: **can be referenced by number* HS-ETS1-3 - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and	**Success Criteria** (e.g.. Learning progression, rubric, proficiency scale, etc.) HS-ETS1-3
	Sample Assessment (e.g. Performance tasks, anchor of student work, common assessment etc.) Students will work in groups to make proposals about the most effective ways to mitigate an impact of climate change on our community. Examples of impacts the student groups may choose include increased flood events, increased wildfire events, and

<table>
<tr><td>environmental impacts.</td><td>decreased biodiversity in the SF Bay. Students will present their proposals to a panel of stakeholders from our community.</td></tr>
<tr><th colspan="2">Stage 3 – Learning Plan</th></tr>
<tr><td rowspan="3">Learning Goals Addressed:
*can be referenced by number

LS4.C: Adaptation

ESS2.D: Weather and Climate

ESS2.D: Global Climate Change

SEP: Analyzing and Interpreting Data

CCC: Systems and Systems Models</td><td>Sample Assignment:
Students will read a news article from Science Daily about how the American pika population of the Eastern Sierras is affected by global warming. Students will answer analysis questions on the article and participate in a class discussion about the phenomenon.</td></tr>
<tr><td>Sample Lab:
To investigate why water is able to moderate climates, students will complete a lab in which they compare how quickly three substances - water, sand, and soil - warm up and cool down. They will gather data that reflects water’s high specific heat and therefore moderating effects on local climate.</td></tr>
<tr><td>Differentiated Approaches: Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended).

We highly recommend teachers vary instructional strategies according to the needs of their students. Many students, including English learners and special education students, will benefit from the use pre-reading activities, graphic organizers, small group discussion scaffolds, flexible assignment due dates, and competency-based assessment.

In the context of the sample assignment, online resources such as Newsela can be used to alter the lexicon difficulty to make an article more accessible to language learners or those generally struggling to read at grade level. Students could also work in heterogeneous partner groups to analyze the article. Teachers should consider providing sentence starters to better help students with the analysis.

Advanced students could be encouraged to research other organisms that are being affected by global warming and climate change. Or they could be encouraged to research other effects such as sudden Oak death.</td></tr>
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Be sure unit and assignment descriptions demonstrate the curriculum meets the A-G subject area course criteria. Review UC A-G requirements at http://www.ucop.edu/agguide/a-g-requirements/

Instructional Materials:

Suggested textbook(s), materials, equipment and resources ● NGSS and NSTA websites and online resources ● California Science Framework aligned text resources ● Discovery Education Online Textbook ● Access to laptops and chromebooks for online simulations such as Phet activities and PBS interactive websites. ● Adequate life and earth science lab material and equipment. In addition to ongoing consumable expenses, the course will require initial capital expenses to fund permanent equipment.	