TAMALPAIS UNION HIGH SCHOOL DISTRICT

Living Earth Course of Study

Overview Information

Title of Course: Living Earth	
Course Author(s): Grace Backer, Jenny Brown, Jamie Garcia, Suzanne Garcia, Kelsey Kniesche, Alan Nealley, Alyssa Sandner	Schools where the course will be taught: Archie Williams, Tamalpais, Redwood, San Andreas and Tamiscal
Length of Course: 1 year (2 semesters)	Subject Area and Discipline: Science
Grade Levels: 10, 11	Is this course an integrated course? No
Is this course being submitted for possible UC honors designation? No	Are you seeking UC approval? If so, in what area (A-G)?
Prerequisites (required or recommended): none	Co-requisites (required or recommended): none
If there are prerequisites for the course, please include a justification as to why they are in place:	
Check all that apply: ✅ UC A-G course ✅ Graduation Requirement (specify the requirement this course meets) ❑ Elective ❑ Honors/AP ❑ CTE	

Introduction to the Course

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, Structure, Function and Growth, Inheritance of Traits, and Evidence of Common Ancestry and Diversity.

At the teacher's discretion, various phenomena are used to frame student learning, therefore performance expectations reflected in one unit may be taught in another unit. Additionally, student learning experiences may include different SEPs and CCCs than those stated in a given NGSS

Performance Expectation while ensuring students practice and apply all SEPs and CCCs at different times throughout the course.

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.

Science & Engineering Practices

1. Questions (for science) & Defining Problems (for engineering)
2. Developing & Using Models
3. Planning & Carrying Out Investigations
4. Analyzing & Interpreting Data
5. Mathematics & Computational Thinking
6. Construct Explanations (for science) & Designing Solutions (for engineering)
7. Engaging in Argument from Evidence
8. Obtain, Evaluate, Communicate Information

Crosscutting Concepts

1. Patterns
2. Cause & Effect: Mechanism & Explanation
3. Scale, Proportion, & Quantity
4. Systems & System Models
5. Energy & Matter: Flow, Cycle, Conservation
6. Structure & Function
7. Stability & Change

Unit Title: Ecosystem Interactions and Energy

Unit Summary:
Through investigations with complex data sets and hands-on simulations, students will investigate a variety of exemplar ecosystems to discover how natural stable systems are organized and how they adapt (or don't) to change. Students will analyze the following: how limiting factors impact carrying capacity, how group behavior impacts survival, and how biodiversity supports ecosystem resilience. Students will engage with real-world conservation dilemmas and explore data and various interest-holder perspectives, to identify the trade-offs humans make as they manage natural resources to support human society as well as the natural systems we live in.

NGSS Performance Expectations:
LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales (Scale, Proportion and Quantity)

LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales (Scale, Proportion and Quantity)

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

LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity (Stability and Change)

LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce (Cause and Effect)

LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity (Cause and Effect)

ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems (Stability and Change)

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

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 (Influence of Science, Engineering, and Technology on Society and the Natural World)

Sample Unit Assignments:

Ecosystem Data Analysis:
Students look at ecosystem field data and organize it to look for patterns to explain group behavior (for example; migration). Students communicate the patterns they figure out on data displays and then co-construct a classroom consensus model to explain what we figured out from the data (one example: we could figure out that some wildebeest are killed by predators, but most wildebeest die of starvation and identify food as the primary limiting factor that drives the migration pattern observed in the data.) Different groups could look at different ecosystem and/or group behaviors

Keystone Species and Biodiversity Case Studies:
Students investigate components of an exemplar ecosystem. Students gather information to develop a model that includes mechanisms and mathematical representations of relationships. We use our models to predict outcomes of disturbances and figure out that biodiversity can support resilience in the system. Students learn:

- Many components of the ecosystem connect to keystone species
- The mechanisms of their interactions include predator/prey, group behavior and competition.
- Keystone species support biodiversity across the entire ecosystem.
- Biodiversity leads to greater stability within the ecosystem because with more species.
- Biodiversity contributes to ecosystem resilience when a disturbance occurs.

Sample Lab:
Students use manipulatives to create a mathematical model and generate evidence to explain how food is a limiting factor that affects the carrying capacity of populations within specific ecosystem conditions. These mathematical representations of data are used to quantify rates of population change over time in order to support explanations about the effect of limiting factors on population size. Students apply the concepts learned in this lab to novel populations and ecosystems as the unit progresses.

Sample unit Assessment:
For a unit transfer task assessment, students are presented with data showing a population (not previously studied, such as African Wild Dog, American Buffalo, etc.) that are struggling to survive. Students analyze data representing various limiting factors such as, habitat maps, predator-prey data, disease data, etc. Based on the data provided, students determine which limiting factors are the

primary cause of the decline. Students write a CER (Claim, Evidence, Reasoning) arguing which limiting factor is the most impactful on whether a new habitat will be able to support and new population.

Unit 2 Title: Carbon's Role in the Living Earth

Unit Summary:
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.

NGSS Performance Expectations:
LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy (Energy and Matter)

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 (Energy and Matter)

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 (Energy and Matter)

LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions

LS2-4. Use mathematical representations to support claims for the cycling of matter and flow energy among organisms in an ecosystem

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 (Systems and System Models)

ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere (Energy and Matter)

ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (Systems and System Models)

ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants (Influence of Science, Engineering, and Technology on Society and the Natural World)

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

Sample Unit Assignments:

Climate Solutions Project
Students act as environmental consultants to investigate and propose a specific mitigation strategy for human-induced climate change, such as regenerative agriculture or blue carbon solutions. Students construct an evidence-based explanation and a digital presentation model that illustrates how their chosen solution restores the balance of the carbon cycle by enhancing carbon sinks or reducing atmospheric CO_2 flux. Students must analyze credible scientific data to evaluate the efficacy and

constraints of their solution, demonstrating a deep understanding of how matter cycles through the biosphere and geosphere. The final product is a collaborative research-based presentation that integrates quantitative reasoning and indigenous or marginalized perspectives to address global environmental equity.

Sample Lab:
Students complete an experiment modeling the reciprocal relationship and byproducts between Photosynthesis and Cellular Respiration in a closed system. Students use either Elodea or Parsley in environments with varying levels of light and bromothymol blue as a ph indicator. The students observe how much carbon is released or conserved (or not if there is not enough light source) by the color change in the solution.

Sample unit Assessment:

Common Assessment: Photosynthesis and Cellular Respiration
Students analyze data from a laboratory investigation using Bromothymol Blue (BTB) as a pH indicator to observe the reciprocal relationship between a producer (Elodea) and a consumer (aquatic snail). Students construct a comparative visual model to illustrate the flow of matter (carbon, oxygen, hydrogen) and the transformation of energy (light to chemical energy/ATP) at both the organismal and cellular levels (chloroplasts and mitochondria).

Unit Title: Structure, Function and Growth

Unit Summary:
Students will learn about the relationships between structure and function of living organisms. Through exploring the phenomena of cancer, students learn about cells, organelles, DNA, the cell cycle and protein synthesis. Students will create a model to explain how alterations to the DNA can impact the likelihood of a person developing cancer.

NGSS Performance Expectations:
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

LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms

LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis (Stability and Change)

LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms (Systems and System Models)

Sample Unit Assignments:

Cell Cycle Microscopy
Students examine prepared microscope slides of the different phases of the cell cycle.

Protein Synthesis Modeling
Students learn about the structure of DNA and how it holds the code to make various proteins. They kinesthetically model the process of transcription (making mRNA) and translation (making a protein) to understand how DNA codes for proteins. The students then go further by manipulating/mutating the DNA, then undergo transcription and translation to create a protein. They discover that the structure of the protein is different, thus the functionality of the protein is different. By the end of the kinesthetic

model, each student creates a paper model showing how DNA determines the structure of proteins, and practice writing CER's to explain how a DNA mutation changes the structure and function of a protein.

Sample Lab:

UV Yeast lab
Students attempt to answer the question: how do genes interact with the environment to affect who gets cancer? Students review and set up an investigation by spreading UV-sensitive and wild-type yeast onto plates and exposing them to chosen designated conditions/UV light. They then make predictions on how the UV radiation will affect the cell's growth and development. Students carefully document and share results with their classmates who have different chosen variables. This lab provides the empirical context necessary for making and defending a claim about how environmental factors cause genetic variation.

Sample unit Assessment:
Students analyze patient data to determine what mechanism has caused the presence of an unfamiliar phenomenon, Age-related Macular Degeneration (AMD). Students make and defend a claim by detailing how a degenerative disorder would occur and what factors could affect how the disorder manifests in different people in the form of a CER.

Unit Title: Inheritance of Traits

Unit Summary:
Students will model how a trait gets passed down from a parent to offspring. Students will construct explanations for how different mechanisms create genetic variation through the movement of chromosomes as germ line cells form gametes in meiosis: independent assortment, crossing over, and fertilization.

NGSS Performance Expectations:
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 (Cause and Effect)

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 (Cause and Effect)

LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population (Scale,
Proportion, and Quantity)

Sample Unit Assignments:
Students use colored pipe cleaners to model homologous chromosomes, exchanging segments to simulate crossing over and separating them through meiosis I and II to represent independent assortment. As they manipulate the models, they track how chromosome number is reduced and how different allele combinations are produced. This hands-on activity helps students visualize the process of meiosis and how genetic variation is created in the process.

Sample Lab:
Students use gel electrophoresis to separate DNA fragments representing different alleles of the Huntington's gene based on size. By comparing banding patterns, they determine whether an individual has two normal alleles, one normal and one affected allele, or two affected alleles. Students connect DNA structure to genetic disorders and interpret evidence to make a diagnosis.

Sample unit Assessment:

Students analyze a model showing the inheritance patterns of two traits within a biological family. Students observe patterns and construct explanations for how variation among offspring arises from processes in meiosis.

Unit Title: Evidence of Common Ancestry and Diversity

Unit Summary:
Students will analyze multiple lines of scientific evidence: including fossils, genetic data, comparative anatomy to explain how ancestry and biological evolution shape diversity of life on Earth. Students will construct and support explanations of natural selection using data, models and their explanation of how traits spread through a population over time.

NGSS Performance Expectations:
LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence (Patterns)

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 (Cause and Effect)

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 (Patterns)

LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations (Cause and Effect)

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 (Cause and Effect)

LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity (Cause and Effect)

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 (Patterns)

ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth (Stability and Change)

Sample Unit Assignments:

Bird Beak Activity
Students model how various "beaks" facilitate feeding on different types of food. Students track the generations over time to observe how they change, and analyze the resulting change in population over time and describe the results with mathematical representation.

Sample Lab:
Students learn aseptic and sterile techniques when exposing *E.coli* to an ampicillin disk. Students then replate bacteria from its first exposure to ampicillin to measure the change in the zone of inhibition to measure the selective pressure of an organism's environment on their inheritance of advantageous heritable traits. In their analysis of their results, students explain the following concepts: the

proliferation of those organisms that are better able to survive and reproduce in the environment and the heritable genetic variation of individuals in a species due to mutation.

Sample unit Assessment:
Students analyze multiple data sets to explain and predict how a population may change over time in response to changing environmental conditions. For example, applying the principles of natural selection as they relate to the changing frequency of the mating call in the Northern Cardinal population in response to rising noise pollution of urbanization.

Recommended Texts and Resources: California Science Dimensions HMH, The Living Earth

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