Tamalpais Union High School District
Larkspur, California

Course of Study

Advanced Placement Biology

Overview

Title of Course: Advanced Placement Biology	
Course Author(s): Wuerth, Kittay, Hayden, Mastromonaco, Nealley	Schools where the course will be taught: Tamalpais, Redwood, Drake
Length of Course: one year (two semesters)	Subject Area and Discipline: Science/Biology
Grade Levels: 11-12	Is this course an integrated course? No
Is this course being submitted for possible UC honors designation? Yes	Are you seeking UC approval? If so, in what area (A-G)? Yes, D lab science
Prerequisites (required or recommended): Chemistry or Physiology	Co-requisites (required or recommended): Chemistry or Physiology
Check all that apply: ✓ **UC A-G course** ❏ Graduation Requirement ✓ **Elective** ✓ **Honors/AP** ❏ ROP	

Introduction

AP Biology focuses on enduring, conceptual understandings and the content that supports them. This approach will enable students to spend less time on factual recall and more time on inquiry-based learning of essential concepts, and will help them develop the reasoning skills necessary to engage in the science practices used throughout their study of AP Biology. The four big ideas of the course are: (1) the process of evolution drives the diversity and unity of life (2) biological systems utilize free energy and molecular building blocks to grow, reproduce, and maintain homeostasis (3) living systems store, receive, transmit and respond to information essential to life processes and (4) biological systems interact and their interactions possess complex properties

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td colspan="3">Unit 1 Title: EVOLUTION- The process of evolution drives the diversity and unity of life.</td></tr>
<tr><td rowspan="7">ESTABLISHED LEARNING GOALS

1.1 The student is able to convert a data set from a table of numbers that reflect a change in the genetic makeup of a population over time and to apply mathematical methods and conceptual understandings to investigate the cause(s) and effect(s) of this change.

1.2 The student is able to evaluate evidence provided by data to qualitatively and/or quantitatively investigate the role of natural selection in evolution.

1.3 The student is able to apply mathematical methods to data from a real or simulated population to predict what will happen to the population in the future.

1.4 The student is able to evaluate data-based evidence that describes evolutionary changes in the genetic makeup of a population over time.

1.5 The student is able to connect evolutionary changes in a population over time to a change in the environment.

1.6 The student is able to use data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and effects of selection in the evolution of specific populations.

1.7 The student is able to justify the selection of data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and the effects of selection in the evolution of specific populations.

1.8 The student is able to make predictions about the effects of genetic drift, migration and artificial selection on the genetic makeup of a population.</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…

Evaluate scientific claims and analyze current issues involving science or technology

Conduct a sound investigation to answer an empirical question

Apply knowledge of science and engineering to engage in public discussions on relevant issues in a changing world

Conduct investigations, both collaboratively and individually, to answer questions

Evaluate scientific claims for validity</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS

Enduring understanding 1.A: Change in the genetic makeup of a population over time is evolution

Enduring understanding 1.B: Organisms are linked by lines of descent from common ancestry.

Enduring understanding 1.C: Life continues to evolve within a changing environment.

Enduring understanding 1.D: The origin of living systems is explained by natural processes</td><td>ESSENTIAL QUESTIONS

What role does evolution play in the organization of living things?

What evidence supports our current model of the origin of living things?

How does the process of evolution drive the unity and diversity of life?

How does life evolve in changing environment?</td></tr>
<tr><td colspan="2">Acquisition</td></tr>
<tr><td>Students will know…</td><td>Students will be skilled at…
1.1 The student can create representations and models</td></tr>
</table>

1.9 The student is able to evaluate evidence provided by data from many scientific disciplines that support biological evolution. 1.10 The student is able to refine evidence based on data from many scientific disciplines that support biological evolution. 1.11 The student is able to design a plan to answer scientific questions regarding how organisms have changed over time using information from morphology, biochemistry and geology. 1.12The student is able to connect scientific evidence from many scientific disciplines to support the modern concept of evolution. 1.13 The student is able to construct and/or justify mathematical models, diagrams or simulations that represent processes of biological evolution. 1.14 The student is able to pose scientific questions that correctly identify essential properties of shared, core life processes that provide insights into the history of life on Earth. 1.15 The student is able to describe specific examples of conserved core biological processes and features shared by all domains or within one domain of life, and how these shared, conserved core processes and features support the concept of common ancestry for all organisms. 1.16 The student is able to justify the scientific claim that organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. 1.17 The student is able to pose scientific questions about a group of organisms whose relatedness is described by a phylogenetic tree or cladogram in order	Essential knowledge 1.A.1: Natural selection is a major mechanism of evolution Essential knowledge 1.A.2: Natural selection acts on phenotypic variations in populations Essential knowledge 1.A.3: Evolutionary change is also driven by random processes. Essential knowledge 1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics Essential knowledge 1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today Essential knowledge 1.B.2: Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested. Essential knowledge 1.C.1: Speciation and extinction have occurred throughout the Earth's history Essential knowledge 1.C.2: Speciation may occur when two populations become reproductively isolated from each other.	of natural or man-made phenomena and systems in the domain. 1.2 The student can describe representations and models of natural or man-made phenomena and systems in the domain. 1.3 The student can refine representations and models of natural or man-made phenomena and systems in the domain. 1.4 The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively. 1.5 The student can re-express key elements of natural phenomena across multiple representations in the domain. 2.1 The student can justify the selection of a mathematical routine to solve problems. 2.2 The student can apply mathematical routines to quantities that describe natural phenomena. 2.3 The student can estimate numerically quantities that describe natural phenomena. 3.1 The student can *pose scientific questions*. 3.2 The student can *refine scientific questions*. 3.3 The student can *evaluate scientific questions*

to (1) identify shared characteristics, (2) make inferences about the evolutionary history of the group, and (3) identify character data that could extend or improve the phylogenetic tree. 1.18 The student is able to evaluate evidence provided by a data set in conjunction with a phylogenetic tree or a simple cladogram to determine evolutionary history and speciation. 1.19 The student is able create a phylogenetic tree or simple cladogram that correctly represents evolutionary history and speciation from a provided data set. 1.20 The student is able to analyze data related to questions of speciation and extinction throughout the Earth's history. 1.21 The student is able to design a plan for collecting data to investigate the scientific claim that speciation and extinction have occurred throughout the Earth's history. 1.22 The student is able to use data from a real or simulated population(s), based on graphs or models of types of selection, to predict what will happen to the population in the future. 1.23 The student is able to justify the selection of data that address questions related to reproductive isolation and speciation. 1.24 The student is able to describe speciation in an isolated population and connect it to change in gene frequency, change in environment, natural selection and/or genetic drift. 1.25 The student is able to describe a model that represents evolution within a population.	Essential knowledge 1.C.3: Populations of organisms continue to evolve Essential knowledge 1.D.1: There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence Essential knowledge 1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.	4.1 The student can *justify the selection of the kind of data* needed to answer a particular scientific question 4.2 The student can design a plan for collecting data to answer a scientific question. 4.3 The student can *collect data* to answer a particular scientific question. 4.4 The student can *evaluate sources of data* to answer a particular scientific question 5.1 The student can *analyze data* to identify patterns or relationships 5.2 The student can *refine observations and measurements* based on data analysis 5.3 The student can *evaluate the evidence provided by data sets* in relation to a particular scientific question 6.1 The student can *justify claims with evidence* 6.2 The student can *construct explanations of phenomena based on evidence* produced through scientific practices 6.3 The student can *articulate the reasons that scientific explanations and theories are refined or replaced.* 6.4 The student can *make claims and predictions about natural phenomena* based on scientific theories and models

1.26The student is able to evaluate given data sets that illustrate evolution as an ongoing process. 1.27 The student is able to describe a scientific hypothesis about the origin of life on Earth. 1.28 The student is able to evaluate scientific questions based on hypotheses about the origin of life on Earth. 1.29 The student is able to describe the reasons for revisions of scientific hypotheses of the origin of life on Earth. 1.30 The student is able to evaluate scientific hypotheses about the origin of life on Earth. 1.31 The student is able to evaluate the accuracy and legitimacy of data to answer scientific questions about the origin of life on Earth. 1.32 The student is able to justify the selection of geological, physical, and chemical data that reveal early Earth conditions.		6.5 The student can *evaluate alternative scientific explanations*. 7.1 The student can *connect phenomena and models* across spatial and temporal scales 7.2 The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas

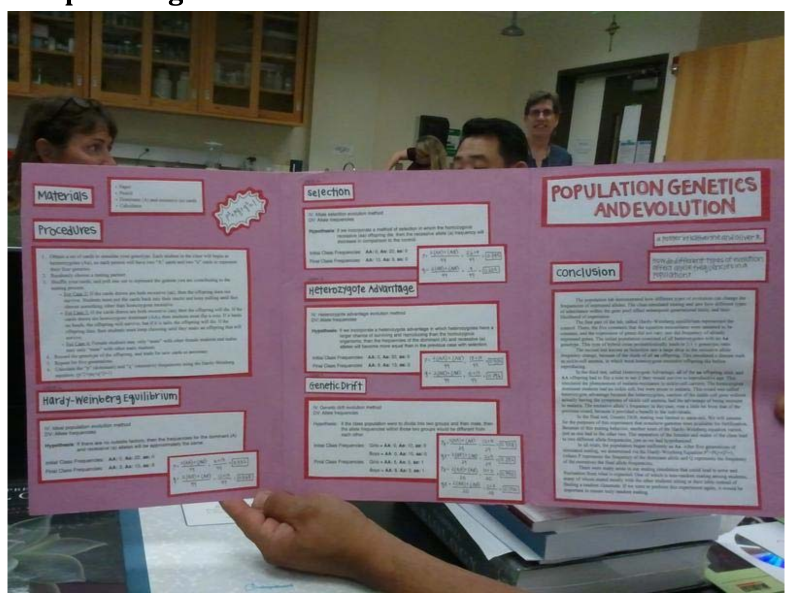
Summary of key learning in this unit:

Evolution is a change in the genetic makeup of a population over time, with natural selection its major driving mechanism. Darwin's theory, which is supported by evidence from many scientific disciplines, states that inheritable variations occur in individuals in a population. Due to competition for limited resources, individuals with more favorable variations or phenotypes are more likely to survive and produce more offspring, thus passing traits to future generations.

Naturally occurring catastrophic and human induced events as well as random environmental changes can result in alteration in the gene pools of populations. Small populations are especially sensitive to these forces. A diverse gene pool is vital for the survival of species because environmental conditions change. Mathematical approaches are used to calculate changes in allele frequency, providing evidence for the occurrence of evolution in a population. Phylogenetic trees graphically model evolutionary history and "descent with modification." However, some organisms and viruses are able to transfer genetic information horizontally.

Stage 2 - Evidence	
Learning Goals Measured: Learning Objectives 1.1 through 1.32	**Success Criteria** [**Sample LAB POSTER RUBRIC**] **Sample Assessment** https://docs.google.com/document/d/1Ru3EQGvfoMjfMA5GFFIZr4O-UUr7vluws0C-xh5LJRM/edit?usp=sharing See Attached Lab Poster

Stage 3 – Learning Plan	
Learning Goals Addressed: Learning Objectives 1.1 through 1.32	**Sample Assignment:**



Student makes a hypothesis about a scientific phenomenon, generates a hypothesis about it, plans and executes and experiment and gathers data to either support or refute their hypothesis, then presents their results in a lab poster to be evaluated by both their instructor and their peers.

Differentiated Approaches:
Students can use a variety of learning modalities to execute their experiment and present their data.

Using bioinformatics resources available online, students will use DNA evidence to support a hypothesis regarding the correct placement of a fossil on a phylogenetic tree.

Students will create a mathematical model of the Hardy-Weinberg equilibrium and manipulate the variables in the model to illustrate the effects of heterozygote advantage, small

	population sizes, bottleneck effect, etc. of the student's choosing.

<table>
<tr><th colspan="2">Stage 1 Desired Results</th></tr>
<tr><td colspan="2">Unit 2 Title: ENERGY - Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.</td></tr>
<tr><td rowspan="4">ESTABLISHED LEARNING GOALS

2.1 The student is able to explain how biological systems use free energy based on empirical data that all organisms require constant energy input to maintain organization, to grow, and to reproduce.

2.2 The student is able to justify a scientific claim that free energy is required for living systems to maintain organization, to grow, or to reproduce, but that multiple strategies for obtaining and using energy exist in different living systems.

2.3 The student is able to predict how changes in free energy availability affect organisms, populations, and/or ecosystems.

2.4 The student is able to use representations to pose scientific questions about what mechanisms and structural features allow organisms to capture, store and use free energy.

2.5 The student is able to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy.

2.6 The student is able to evaluate data to show the relationship between photosynthesis and respiration in the flow of free energy through a system.

2.7 The student is able to use calculated surface area-to-volume ratios to predict</td><td>Transfer</td></tr>
<tr><td>Students will be able to independently use their learning to…

Based on surface-to-volume ratios, predict which cell(s) might eliminate wastes or procure nutrients faster by diffusion

Determine the isotonic conditions of cells given data on cellular responses to varying solutions

Make predictions about cellular responses to hypotonic, hypertonic, and isotonic conditions

Use heart rate and blood pressure data to evaluate the health of the cardiovascular system

Make predictions about the likely results of changes in homeostatic mechanisms

Use free energy calculations to predict whether a chemical reaction is likely to proceed spontaneously or not

Make predictions about the behavior of enzymes in different environmental conditions such as changing temperature, pH, and salinity

Use data to determine optimal conditions for photosynthesis in plants

Use data to determine optimal conditions for cellular respiration in organisms

Make predictions about the effects of photorespiration of plants

Make predictions about plant metabolism in different habitats</td></tr>
<tr><td>Meaning Making</td></tr>
</table>

which cell(s) might eliminate wastes or procure nutrients faster by diffusion. 2.8 Students will be able to explain how cell size and shape affect the overall rate of nutrient intake and the rate of waste elimination. 2.9 The student is able to justify the selection of data regarding the types of molecules that an animal, plant or bacterium will take up as necessary building blocks and excrete as waste products. 2.10 The student is able to represent graphically or model quantitatively the exchange of molecules between an organism and its environment, and the subsequent use of these molecules to build new molecules that facilitate dynamic homeostasis, growth and reproduction. 2.11 The student is able to use representations and models to pose scientific questions about the properties of cell membranes and selective permeability based on molecular structure. 2.12 The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function. 2.13 The student is able to use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasis is maintained by the active movement of molecules across membranes. 2.14 The student is able to explain how internal membranes and organelles contribute to cell functions. 2.15 The student is able to use representations and models to describe differences in prokaryotic and eukaryotic cells.	UNDERSTANDINGS Explain how chemical and electrochemical gradients are established Compare and contrast plant and animal cells Distinguish between passive and active transport Explain the relationship between structure and function in cell membranes Distinguish between hypotonic, hypertonic, and isotonic solutions Describe the functions of membrane functions Describe the hierarchical organization of body plans in animals Explain how animals establish and maintain coordination and control Provide examples of positive and negative feedback control Describe homeostatic processes for thermoregulation Distinguish between open and closed circulatory systems Describe blood flow through the mammalian heart Summarize blood composition Explain how mammals breathe	ESSENTIAL QUESTIONS How do organisms acquire and use energy? How do organisms maintain homeostasis?

2.16 The student can justify a claim made about the effect(s) on a biological system at the molecular, physiological or organismal level when given a scenario in which one or more components within a negative regulatory system is altered. 2.17 The student is able to connect how organisms use negative feedback to maintain their internal environments 2.18 The student is able to evaluate data that show the effect(s) of changes in concentrations of key molecules on negative feedback mechanisms. 2.19 The student can make predictions about how organisms use negative feedback mechanisms to maintain their internal environments. 2.20 The student is able to make predictions about how positive feedback mechanisms amplify activities and processes in organisms based on scientific theories and models. 2.21 The student is able to justify that positive feedback mechanisms amplify responses in organisms. 2.22 The student is able to justify the selection of the kind of data needed to answer scientific questions about the relevant mechanism that organisms use to respond to changes in their external environment. 2.23 The student is able to pose a scientific question concerning the behavioral or physiological response of an organism to a change in its environment. 2.24 The student is able to refine scientific models and questions about the effect of complex biotic and abiotic interactions on all biological systems, from cells and organisms to populations, communities and ecosystems. 2.25 The student is able to design a plan for collecting data to show that all	Distinguish between osmoregulation strategies observed in different vertebrate groups Describe the structure and function of the human kidney Describe the hormonal circuits that link kidney function, water balance and blood pressure Describe how free energy is determined using enthalpy, temperature, and entropy in a system Summarize the ATP cycle involved in metabolism Explain the four mechanisms used by enzymes to catalyze reactions Distinguish between glycolysis, the Krebs cycle, and electron transport chain Explain how the proton motive force drives ATP synthesis Explain the importance of phosphofructokinase in cellular respiration Distinguish between aerobic and anaerobic cellular respiration pathways Distinguish between the light reactions and Calvin cycle Distinguish between CAM, C4, and C3 Compare and contrast cellular respiration and photosynthesis Describe the metabolic efficiency of cellular	

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<td rowspan="3">biological systems (cells, organisms, populations, communities and ecosystems) are affected by complex biotic and abiotic interactions.

2.26 The student is able to analyze data to identify possible patterns and relationships between a biotic or abiotic factor and a biological system (cells, organisms, populations, communities or ecosystems).

2.27 The student can construct explanations based on scientific evidence that homeostatic mechanisms reflect continuity due to common ancestry and/or divergence due to adaptation in different environments.

2.28 The student is able to analyze data to identify phylogenetic patterns or relationships, showing that homeostatic mechanisms reflect both continuity due to common ancestry and change due to evolution in different environments.

2.29 The student is able to connect differences in the environment with the evolution of homeostatic mechanisms.

2.30 The student is able to use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems.

2.31 The student can create representations and models to describe immune responses.

2.32 The student can create representations or models to describe nonspecific immune defenses in plants and animals.

2.33 The student is able to connect the concept of cell communication to the functioning of the immune system.

2.34 The student is able to design a plan for collecting data to support the scientific</td>
<td>respiration and photosynthesis</td>
<td></td>
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<tr>
<th colspan="2">Acquisition</th>
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<tr>
<td>Students will know…

2.A.1:All living systems require constant input of free energy.

2.A.2: Organisms capture and store free energy for use in biological processes.

2.A.3: Organisms must exchange matter with the environment to grow, reproduce and maintain organization.

2.B.1: Cell membranes are selectively permeable due to their structure.

2.B.2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.

2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.

2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.

2.C.2: Organisms respond to changes in their external environments.

2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic</td>
<td>Students will be skilled at…

1.1 The student can create representations and models of natural or man-made phenomena and systems in the domain.

1.2 The student can describe representations and models of natural or man-made phenomena and systems in the domain.

1.3 The student can refine representations and models of natural or man-made phenomena and systems in the domain.

1.4 The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively.

1.5 The student can re-express key elements of natural phenomena across multiple representations in the domain.

2.1 The student can justify the selection of a mathematical routine to solve problems.

2.2 The student can apply mathematical routines to quantities that describe natural phenomena.

2.3 The student can estimate numerically quantities that describe natural phenomena.</td>
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</table>

claim that the timing and coordination of physiological events involve regulation. 2.35 The student is able to justify scientific claims with evidence to show how timing and coordination of physiological events involve regulation. 2.36 The student is able to connect concepts that describe mechanisms that regulate the timing and coordination of physiological events. 2.37 The student is able to analyze data to support the claim that responses to information and communication of information affect natural selection. 2.38 The student is able to justify scientific claims, using evidence, to describe how timing and coordination of behavioral events in organisms are regulated by several mechanisms. 2.39 The student is able to connect concepts in and across domain(s) to predict how environmental factors affect responses to information and change behavior.	interactions involving exchange of matter and free energy. **2.D.2**: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments. **2.D.3**: Biological systems are affected by disruptions to their dynamic homeostasis. **2.D.4**: Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis. **2.E.1**: Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms. **2.E.2**: Timing and coordination of physiological events are regulated by multiple mechanisms. **2.E.3**: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.	3.1 The student can *pose scientific questions*. 3.2 The student can *refine scientific questions*. 3.3 The student can *evaluate scientific questions*. 4.1 The student can *justify the selection of the kind of data* needed to answer a particular scientific question. 4.2 The student can *design a plan* for collecting data to answer a particular scientific question. 4.3 The student can *collect data* to answer a particular scientific question. 4.4 The student can *evaluate sources of data* to answer a particular scientific question. 5.1 The student can *analyze data* to identify patterns or relationships. 5.2 The student can *refine observations and measurements* based on data analysis. 5.3 The student can *evaluate the evidence provided by data sets* in relation to a particular scientific question. 6.1 The student can *justify claims with evidence*. 6.2 The student can *construct explanations of phenomena based on evidence* produced through scientific practices. 6.3 The student can *articulate the reasons that scientific*

		explanations and theories are refined or replaced. 6.4 The student can *make claims and predictions about natural phenomena* based on scientific theories and models. 6.5 The student can *evaluate alternative scientific explanations*. 7.1 The student can *connect phenomena and models* across spatial and temporal scales. 7.2 The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

Summary of key learning in this unit:

Living systems require free energy and matter to maintain order, grow and reproduce. Organisms employ various strategies to capture, use and store free energy and other vital resources: photosynthesis traps free energy present in sunlight that, in turn, is used to produce carbohydrates from carbon dioxide; cellular respiration and fermentation harvest free energy from sugars to produce free energy carriers, including ATP.

Cells and organisms must exchange matter with the environment (e.g. water and nutrients are used in the synthesis of new molecules; carbon moves from the environment to organisms where it is incorporated into carbohydrates, proteins, nucleic acids or fats; and oxygen is necessary for more efficient free energy use in cellular respiration). One of the ways that cells exchange matter with the environment is through their specialized membranes, which allow cells to create and maintain internal environments that differ from external environments.

Organisms also have feedback mechanisms that maintain dynamic homeostasis by allowing them to respond to changes in their internal and external environments. Negative feedback loops maintain optimal internal environments, and positive feedback mechanisms amplify responses.

Stage 2 - Evidence

Learning Goals Measured: **can be referenced by number* 2.1 - 2.39	**Success Criteria** (e.g.. Learning progression, rubric, proficiency scale, etc.) Metabolism Cell Structure and Organization Animal Physiology

	Sample Assessment The students take multiple choice tests and answer free-response questions similar to those seen on the AP Biology exam. The students create lab reports about their findings in lab.
Stage 3 – Learning Plan	
Learning Goals Addressed: **can be referenced by number* 2.1-2.39	**Sample Assignment:** Students will work in groups to conduct investigations on the variables that influence metabolism rates in different organisms (peas, crickets). Students will write a lab report about their results. Students will learn how temperature, salinity and pH affect metabolism rates.
	Differentiated Approaches: Background information for the lab is presented in a variety of formats - visuals, hands on activities, slide decks, small and large group discussions.

Stage 1 Desired Results		
Unit 3 Title: INFORMATION **- Living systems store, retrieve, transmit and respond to information essential to life processes.**		
ESTABLISHED LEARNING GOALS 3.1 The student is able to construct scientific explanations that use the structures and mechanisms of DNA and RNA to support the claim that DNA and, in some cases, RNA are the primary sources of heritable information. 3.2 The student is able to justify the selection of data from historical investigations that support the claim that DNA is the source of heritable information. 3.3 The student is able to describe representations and models that illustrate how genetic information is copied for transmission between generations. 3.4 Learning objective 3.4The student is able to describe representations and models illustrating how genetic information is translated into polypeptides.	***Transfer*** *Students will be able to independently use their learning to…* Evaluate scientific claims and analyze current issues involving science or technology Conduct a sound investigation to answer an empirical question Apply knowledge of science and engineering to engage in public discussions on relevant issues in a changing world Conduct investigations, both collaboratively and individually, to answer questions Evaluate scientific claims for validity ***Meaning Making***	
	UNDERSTANDINGS *Students will understand that…*	ESSENTIAL QUESTIONS **Genetics and Information Transfer:**

<table>
<tr>
<td rowspan="3">3. 5 The student can explain how heritable information can be manipulated using common technologies.

3.6 The student can predict how a change in a specific DNA or RNA sequence can result in changes in gene expression.

3.7 The student can make predictions about natural phenomena occurring during the cell cycle.

3.8 The student can describe the events that occur in the cell cycle.

3.9 The student is able to construct an explanation, using visual representations or narratives, as to how DNA in chromosomes is transmitted to the next generation via mitosis, or meiosis followed by fertilization.

3.10 The student is able to represent the connection between meiosis and increased genetic diversity necessary for evolution.

3.11 The student is able to evaluate evidence provided by data sets to support the claim that heritable information is passed from one generation to another generation through mitosis, or meiosis followed by fertilization.

3.12 The student is able to construct a representation that connects the process of meiosis to the passage of traits from parent to offspring.

3.13 The student is able to pose questions about ethical, social or medical issues surrounding human genetic disorders.

3.14 The student is able to apply mathematical routines to determine Mendelian patterns of inheritance provided by data sets.

3.15 The student is able to explain deviations from Mendel's model of the inheritance of traits.</td>
<td>Enduring understanding 3.A: Heritable information provides for continuity of life.

Enduring understanding 3.B: Expression of genetic information involves cellular and molecular mechanisms.

Enduring understanding 3.C: The processing of genetic information is imperfect and is a source of genetic variation.</td>
<td>How are traits passed from one generation to the next?

How do eukaryotic cells store, retrieve, and transmit genetic information?

How does genotype affect phenotype?

How are genotype and human disorder related?

How does gene expression control the cell and determine its metabolism?

What are the current trends in genetic engineering techniques that guide manipulation of genetic information?

What social and ethical issues are raised by advances in genetic engineering?</td>
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<tr>
<td colspan="2">Acquisition</td>
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<tr>
<td>Students will know…
Essential knowledge 3.A.1:DNA, and in some cases RNA, is the primary source of heritable information.

Essential knowledge 3.A.2: In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.

Essential knowledge 3.A.3: The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of</td>
<td>Students will be skilled at…
1.1 The student can create representations and models of natural or man-made phenomena and systems in the domain.

1.2 The student can describe representations and models of natural or man-made phenomena and systems in the domain.

1.3 The student can refine representations and models of natural or man-made phenomena and systems in the domain.</td>
</tr>
</table>

3.16 The student is able to explain how the inheritance patterns of many traits cannot be accounted for by Mendelian genetics. 3.17 The student is able to describe representations of an appropriate example of inheritance patterns that cannot be explained by Mendel's model of the inheritance of traits. 3.18 The student is able to describe the connection between the regulation of gene expression and observed differences between different kinds of organisms. 3.19 The student is able to describe the connection between the regulation of gene expression and observed differences between individuals in a population. 3.20 The student is able to explain how the regulation of gene expression is essential for the processes and structures that support efficient cell function. 3.21 The student can use representations to describe how gene regulation influences cell products and function. 3.22 The student is able to explain how signal pathways mediate gene expression, including how this process can affect protein production. 3.23 The student can use representations to describe mechanisms of the regulation of gene expression. 3.24 The student is able to predict how a change in genotype, when expressed as a phenotype, provides a variation that can be subject to natural selection 3.25 The student can create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced. 3.26 The student is able to explain the connection between genetic variation in	genes from parent to offspring Essential knowledge 3.A.4: The inheritance pattern of many traits cannot be explained by simple Mendelian genetics. Essential knowledge 3.B.1: Gene regulation results in differential gene expression, leading to cell specialization. Essential knowledge 3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene expression. Essential knowledge 3.C.1: Changes in genotype can result in changes in phenotype. Essential knowledge 3.C.2: Biological systems have multiple processes that increase genetic variation.	1.4 The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively. 1.5 The student can *reexpress key elements* of natural phenomena across multiple representations in the domain. 2.1 The student can *justify the selection of a mathematical routine* to solve problems. 2.2 The student can *apply mathematical routines* to quantities that describe natural phenomena. 2.3 The student can *estimate numerically* quantities that describe natural phenomena. 3.1 The student can *pose scientific questions*. 3.2 The student can *refine scientific questions*. 3.3 The student can *evaluate scientific questions*. 4.1 The student can *justify the selection of the kind of data* needed to answer a particular scientific question. 4.2 The student can *design a plan* for collecting data to answer a particular scientific question. 4.3 The student can *collect data* to answer a particular scientific question.

organisms and phenotypic variation in populations. 3.27 The student is able to compare and contrast processes by which genetic variation is produced and maintained in organisms from multiple domains. 3.28 The student is able to construct an explanation of the multiple processes that increase variation within a population. 3.29 The student is able to construct an explanation of how viruses introduce genetic variation in host organisms. 3.30 The student is able to use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population. 3.31 The student is able to describe basic chemical processes for cell communication shared across evolutionary lines of descent. 3.32 The student is able to generate scientific questions involving cell communication as it relates to the process of evolution. 3.33 The student is able to use representation(s) and appropriate models to describe features of a cell signaling pathway. 3.34 The student is able to construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling. 3.35 The student is able to create representation(s) that depict how cell-to-cell communication occurs by direct contact or from a distance through chemical signaling. 3.36 The student is able to describe a model that expresses the key elements of signal transduction pathways by which a signal is converted to a cellular response.		4.4 The student can *evaluate sources of data* to answer a particular scientific question. 5.1 The student can *analyze data* to identify patterns or relationships. 5.2 The student can *refine observations and measurements* based on data analysis. 5.3 The student can *evaluate the evidence provided by data sets* in relation to a particular scientific question. 6.1 The student can *justify claims with evidence*. 6.2 The student can *construct explanations of phenomena based on evidence* produced through scientific practices. 6.3 The student can *articulate the reasons that scientific explanations and theories are refined or replaced*. 6.4 The student can *make claims and predictions about natural phenomena* based on scientific theories and models. 6.5 The student can *evaluate alternative scientific explanations*. 7.1 The student can *connect phenomena and models* across spatial and temporal scales. 7.2 The student can *connect concepts* in and across domain(s) to generalize or

3.37 The student is able to justify claims based on scientific evidence that changes in signal transduction pathways can alter cellular response. 3.38 The student is able to describe a model that expresses key elements to show how change in signal transduction can alter cellular response. 3.39 The student is able to construct an explanation of how certain drugs affect signal reception and, consequently, signal transduction pathways. 3.40 The student is able to analyze data that indicate how organisms exchange information in response to internal changes and external cues, and which can change behavior. 3.41 The student is able to create a representation that describes how organisms exchange information in response to internal changes and external cues, and which can result in changes in behavior. 3.42 The student is able to describe how organisms exchange information in response to internal changes or environmental cues. 3.43 The student is able to construct an explanation, based on scientific theories and models, about how nervous systems detect external and internal signals, transmit and integrate information, and produce responses. 3.44 The student is able to describe how nervous systems detect external and internal signals. 3.45 The student is able to describe how nervous systems transmit information. 3.46 The student is able to describe how the vertebrate brain integrates information to produce a response.		extrapolate in and/or across enduring understandings and/or big ideas.

3.47 The student is able to create a visual representation of complex nervous systems to describe/explain how these systems detect external and internal signals, transmit and integrate information, and produce responses. 3.48 The student is able to create a visual representation to describe how nervous systems detect external and internal signals. 3.49 The student is able to create a visual representation to describe how nervous systems transmit information. 3.50 The student is able to create a visual representation to describe how the vertebrate brain integrates information to produce a response.		

Summary of key learning in this unit:

Genetic information provides for continuity of life and, in most cases, this information is passed from parent to offspring via DNA. The double-stranded structure of DNA provides a simple and elegant solution for the transmission of heritable information to the next generation; by using each strand as a template, existing information can be preserved and duplicated with high fidelity within the replication process. While the process of replication is imperfect, and errors occur through chemical instability and environmental impacts (e.g. mutations which can lead to heritable conditions), cells have multiple mechanisms to correct errors to protect against changes in the original sequence.

Mendel was able to describe a model of inheritance of traits, and his work represents an application of mathematical reasoning to a biological problem. However, most traits result from interactions of many genes and do not follow Mendelian patterns of inheritance. Understanding the genetic basis of specific phenotypes and their transmission in humans can raise social and ethical issues.

Genetic variation is almost always advantageous for the long-term survival and evolution of a species. In sexually reproducing organisms, meiosis produces haploid gametes, and random fertilization produces diploid zygotes. In asexually reproducing organisms, variation can be introduced through mistakes in DNA replication or repair and through recombination; additionally, bacteria can transmit and/or exchange genetic information horizontally (between individuals in the same generation).

Stage 2 - Evidence

Learning Goals Measured:	**Success Criteria**:
**can be referenced by number* Learning Objectives 3.1-3.50	Sample LAB POSTER RUBRIC, Sample of Exam "Must Knows" (for genetics exam) CHAPTER 13 – Meiosis and Sexual Life Cycles Concept 13.1 – Offspring acquire genes from parents by inheriting chromosomes.

	Concept 13.2 – Fertilization and meiosis alternate in sexual life cycles. Concept 13.3 – Meiosis reduces the number of chromosome sets from diploid to haploid. Concept 13.4 – Genetic variation produced in sexual life cycles contributes to evolution. CHAPTER 14 – Mendel and the Gene Idea Concept 14.1 – Mendel used the scientific approach to identify two laws of inheritance. Concept 14.2 – The laws of probability govern Mendelian inheritance. Concept 14.3 – Inheritance patterns are often more complex than predicted by simple Mendelian genetics. Concept 14.4 –Many human traits follow Mendelian patterns of inheritance. CHAPTER 15 –The Chromosomal Basis of Inheritance Concept 15.1 – Mendelian inheritance has its physical basis in the behavior of chromosomes. Concept 15.2 –Sex-linked genes exhibit unique patterns of inheritance. Concept 15.3 – Linked genes tend to be inherited together because they are located near each other on the same chromosome. Concept 15.4 – Alterations of chromosome number or structure cause some genetic disorders. Concept 15.5 – Some inheritance patterns are exceptions to standard Mendelian inheritance. **Laboratory Investigations:** Meiosis in *Sordaria fimicola* ; Corn Genetics: ● Understand the mechanisms of Meiosis and the Cell Cycle ● Understand the role of crossing over in Meiosis. ● Use microscope skills to identify spore arrangement in *Sordaria*. ● Use models to represent the process of Meiosis. ● Conduct an experiment to explore the genetics of Corn and conduct a Chi Square Analysis on the results obtained. ● Understand how to do monohybrid, dihybrid, and test crosses. ● Scientific Skills and Practice ● Forming hypotheses ● Use models to understand the phases of meiosis and the crossing over ● Experimental Design ● Microscope and Slide preparation skills ● Using Chi Square Analysis to analyze experimental results

	Sample Assessment : The students take multiple choice tests and answer free-response questions similar to those seen on the AP Biology exam. The students create group lab presentations about their findings in lab (Experiments in this unit: ELISA assay, Gel Electrophoresis Lab, Mitosis/Cell Cycle Investigation, Meiosis in Sordaria, AP Gene for Green, Corn Genetics Lab, Modeling Transcription and Translation, pGLO lab) Additional projects for this unit: Cell Communication Project, Human Genetics Disorder Project
Stage 3 – Learning Plan	
Learning Goals Addressed: **can be referenced by number* Learning Objectives: 3.3 3.4, 3.6, 3.7, 3.12, 3.13, 3.14	**Sample Assignment:** Human Genetics Disorder Project: In this activity, students will be exploring the process of how human genetic disorders are inherited and how they develop. They focus on a specific genetic condition and research how that particular condition shapes an individual. They create a brochure aimed toward explaining the cause, symptoms, and incidence rates of the diseases. Students complete a summary chart to learn more about the other disorders: How they are caused (autosomal dominant, autosomal recessive, sex-linked, or nondisjunction), and how they manifest. Brochures are be read by classmates to fill out summary chart, and brochures are evaluated by the teacher.
	Differentiated Approaches: Students get to choose their topic, so background interests can drive their choices Completing group project allow different strengths to be utilized: research, organization, graphing abilities, technical and writing skills, graphic/artistic skills, creativity

Stage 1 Desired Results	
Unit 4 Title: INTERACTIONS **- Biological systems interact, and these systems and their interactions possess complex properties.**	
ESTABLISHED LEARNING GOALS (e.g. standards at the local, state and/or national level) **can be referenced by number*	***Transfer*** *Students will be able to independently use their learning to…* Evaluate scientific claims and analyze current issues involving science or technology

<table>
<tr>
<td rowspan="5">4.1 The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties.

4.2 The student is able to refine representations and models to explain how the subcomponents of a biological polymer and their sequence determine the properties of that polymer.

4.3 The student is able to use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule.

4.4 The student is able to make a prediction about the interactions of subcellular organelles.

4.5 The student is able to construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions.

4.6 The student is able to use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions.

4.7 The student is able to refine representations to illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues and organs.

4.8 The student is able to evaluate scientific questions concerning organisms that exhibit complex properties due to the interaction of their constituent parts.

4.9 The student is able to predict the effects of a change in a component(s)</td>
<td colspan="2">Conduct a sound investigation to answer an empirical question

Apply knowledge of science and engineering to engage in public discussions on relevant issues in a changing world

Conduct investigations, both collaboratively and individually, to answer questions

Evaluate scientific claims for validity</td>
</tr>
<tr>
<td colspan="2">Meaning Making</td>
</tr>
<tr>
<td>UNDERSTANDINGS

Enduring understanding 4.A: Interactions within biological systems lead to complex properties.
4.B: Competition and cooperation are important aspects of biological systems.

4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.</td>
<td>ESSENTIAL QUESTIONS

How do interactions between and within populations influence patterns of species distribution and abundance?

How do living things use energy and matter to survive in an environment?

How do humans impact the biodiversity of ecosystems?

What role does the environment play in sustaining homeostasis in biological systems?</td>
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<tr>
<td colspan="2">Acquisition</td>
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<tr>
<td>Students will know…

Essential knowledge 4.A.2: The structure and function of subcellular components, and their interactions,</td>
<td>Students will be skilled at…

1.1 The student can create representations and models of natural or man-made phenomena and systems in the domain.

1.2 The student can describe representations and models of natural or</td>
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of a biological system on the functionality of an organism(s). 4.10 The student is able to refine representations and models to illustrate biocomplexity due to interactions of the constituent parts. 4.11 The student is able to justify the selection of the kind of data needed to answer scientific questions about the interaction of populations within communities. 4.12 The student is able to apply mathematical routines to quantities that describe communities composed of populations of organisms that interact in complex ways. 4.13 The student is able to predict the effects of a change in the community's populations on the community. 4.14 The student is able to apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy. 4.15 The student is able to use visual representations to analyze situations or solve problems qualitatively to illustrate how interactions among living systems and with their environment result in the movement of matter and energy. 4.16 The student is able to predict the effects of a change of matter or energy availability on communities. 4.17 The student is able to analyze data to identify how molecular interactions affect structure and function. 4.18 The student is able to use representations and models to	provide essential cellular processes. 4.A.3 Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs. 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts. 4.A.5: Communities are composed of populations of organisms that interact in complex ways. 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy. 4.B.1: Interactions between molecules affect their structure and function. 4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.	man-made phenomena and systems in the domain. 1.3 The student can refine representations and models of natural or man-made phenomena and systems in the domain. 1.4 The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively. 1.5 The student can reexpress key elements of natural phenomena across multiple representations in the domain. 2.1 The student can justify the selection of a mathematical routine to solve problems. 2.2 The student can apply mathematical routines to quantities that describe natural phenomena. 2.3 The student can estimate numerically quantities that describe natural phenomena. 3.1 The student can *pose scientific questions*. 3.2 The student can *refine scientific questions*. 3.3 The student can *evaluate scientific questions* 4.1 The student can *justify the selection of the kind of data* needed to answer a particular scientific question 4.2 The student can design a plan for collecting data to answer a scientific question.

analyze how cooperative interactions within organisms promote efficiency in the use of energy and matter. 4.19 The student is able to use data analysis to refine observations and measurements regarding the effect of population interactions on patterns of species distribution and abundance. 4.20 The student is able to explain how the distribution of ecosystems changes over time by identifying large-scale events that have resulted in these changes in the past. 4.21 The student is able to predict consequences of human actions on both local and global ecosystems. 4. 22 The student is able to construct explanations based on evidence of how variation in molecular units provides cells with a wider range of functions. 4.23 The student is able to construct explanations of the influence of environmental factors on the phenotype of an organism. 4.24 The student is able to predict the effects of a change in an environmental factor on the gene expression and the resulting phenotype of an organism. 4.25 The student is able to use evidence to justify a claim that a variety of phenotypic responses to a single environmental factor can result from different genotypes within the population. 4.26 The student is able to use theories and models to make scientific claims and/or predictions about the effects of variation within populations on survival and fitness.	4.B.3: Interactions between and within populations influence patterns of species distribution and abundance. 4.B.4: Distribution of local and global ecosystems changes over time. 4.C.1: Variation in molecular units provides cells with a wider range of functions. 4.C.2: Environmental factors influence the expression of the genotype in an organism. 4.C.3: The level of variation in a population affects population dynamics. 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem.	4.3 The student can *collect data* to answer a particular scientific question. 4.4 The student can *evaluate sources of data* to answer a particular scientific question 5.1 The student can *analyze data* to identify patterns or relationships 5.2 The student can *refine observations and measurements* based on data analysis 5.3 The student can *evaluate the evidence provided by data sets* in relation to a particular scientific question 6.1 The student can *justify claims with evidence* 6.2 The student can *construct explanations of phenomena based on evidence* produced through scientific practices 6.3 The student can *articulate the reasons that scientific explanations and theories are refined or replaced*. 6.4 The student can *make claims and predictions about natural phenomena* based on scientific theories and models 6.5 The student can *evaluate alternative scientific explanations*. 7.1 The student can *connect phenomena and models* across spatial and temporal scales 7.2 The student can *connect concepts* in and across domain(s) to generalize or

4.27 The student is able to make scientific claims and predictions about how species diversity within an ecosystem influences ecosystem stability.		extrapolate in and/or across enduring understandings and/or big ideas

Summary of key learning in this unit:

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

Stage 2 - Evidence

Learning Goals Measured: **can be referenced by number* Learning Objectives 4.1 through 4.27	**Success Criteria** Rubric for ecology ad campaign https://docs.google.com/document/d/1iq1NjfVaHqptbFm3TVT-_wq0iH-xPE6n4LJB480vn-U/edit?usp=sharing
	Sample Assessment Students create travel magazines that depict and describe the five different biomes. For each biome, the student will start from the macro level drilling down (biome, country, city/town, specific ecosystem, specific animal, and specific plant). Students explain (with justification) unique adaptations for their selected plant and animal that allow for survival in the biome. Students should include abiotic and biotic factors.

Stage 3 – Learning Plan

Learning Goals Addressed: **can be referenced by number* Learning Objectives 4.1 through 4.27	**Sample Assignment:** Students independently explore an interactive tutorial on circadian rhythms. This tutorial includes examples of measurements of biological rhythms. Students use this activity to explain and justify how timing and coordination of behavioral events in organisms are regulated.
	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).

	Students choose and observe specific behaviors in three different breeds of dogs. In written reports, students describe how dogs exchange information in response to internal changes and external cues. Students make recommendations to determine which type of dog is best suited to live on a farm, in a loft apartment, and/or in a condominium. Students create visual representations that illustrate biocomplexity and interactions in the environment. Each representation should be a depiction across systems (starting from the biosphere and going to the habitat of an organism). The following should also be included: biosphere, biome, ecosystem, community, population, organism, habitat, and niche. Abiotic and biotic factors should be included where applicable. Students create posters that illustrate the effect of a change in matter and energy availability in an ecosystem. Students are self-guided as they describe the trophic structure of the ecosystem and explain how organisms receive inputs of energy and nutrients, where outputs go, and the effects each organism has on the others. They include energy transformations and transfers based on the hypothetical assumption that 10,500 J of net energy is available at the producer level, and they determine the organisms that are placed in each trophic level. Students share their posters with the class for peer review.

Instructional Materials:

Suggested textbook(s), materials, equipment and resources	Campbell Biology in Focus / Edition 2 by Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Primary material Different edition was previously approved by the board AP® Biology investigative Labs: An Inquiry-Based Approach Primary material (free resource from College Board)

Adopted: 5/9/00
Revised: 2/25/04
Revised: 2/6/18
UC Approved (d)