Advanced Placement Biology

https://apcentral.collegeboard.org/pdf/bio-appendixc-apbiologyconceptsataglance.pdf?course=ap-biology

https://apcentral.collegeboard.org/courses/resources/science-practices

https://apcentral.collegeboard.org/pdf/ap-biology-course-and-exam-description-0.pdf

Summit Public Schools
Summit, New Jersey

Grade Level: 11-12
Content Area: Science

Length of Course: Full year

Curriculum

Course Description:

AP Biology is an introductory college-level biology course. Students cultivate their understanding of biology through inquiry-based investigations as they explore the following topics: evolution, cellular processes, energy and communication, genetics, information transfer, ecology, and interactions. Students admitted into this course have been given a strong foundation in physics and chemistry and have shown an aptitude and interest in science.

The AP Biology course is designed to be the equivalent of a two-semester college introductory biology course usually taken by science majors during their first year. The college course in biology differs significantly from the usual first high school course in biology with respect to the kind of textbook used, the range and depth of topics covered, the type of laboratory work done by students, and the time and effort required of students. The textbook used for AP Biology is used in college biology courses. The kinds of labs done by AP students are the equivalent of those done by college students. Through the use of various science practices and spiralling concepts found in the Big Ideas, the AP Biology course aims to provide students with the conceptual framework, factual knowledge, and analytical skills necessary to deal critically with the rapidly changing science of biology.

This curriculum references the current NJ Science standards, The national science standards (NGSS) and the College Board curriculum for AP Biology.

Big Ideas

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 dynamic homeostasis.
3. Living systems store, retrieve, transmit and respond to information essential to life processes.
4. Biological systems interact, and these systems and their interactions possess complex properties.

Major switch to curriculum is the order in which the units are taught, removal of body systems and cells and genetics units broken down :

Old order	New order	% of exam	Class periods per unit (based on 45 minute classes)
Ecology chem cells genetics evolution body systems	Chemistry of Life Cell structure and function Cell energetics Cell communication and cycle Heredity Gene expression and regulation Natural selection Ecology	8-11 10-13 12-16 10-15 8-11 12-16 13-20 10-15	5-7 11-13 14-17 9-11 9-11 18-21 20-23 18-21 **104-124 Days**

Unit 1: Chemistry

5-7 Class periods 8-11% of AP exam

Chapters 1-5 in textbook

Next Generation Science Standards

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.

ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

AP Biology Big Idea

Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.

Big Idea 4. Biological systems interact, and these systems and their interactions possess complex properties.

Big Ideas:

Science and Engineering Practices.

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- **LS4-1** Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- **PS1-3** Plan and conduct an investigation individually and collaboratively to produce data to serve as 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.

Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- **PS1-4** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-
generated sources of evidence consistent with scientific ideas, principles, and theories.

- **PS1-2** Construct and revise 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.

NGSS Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3)

PS1.B: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5)

PS2.B: Types of Interactions

- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

ETS1.C: Optimizing the Design Solution

- 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. (secondary to HS-PS1-6)

LS1.C: Organization for Matter and Energy Flow in Organisms

- 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 matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7)
- 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)

ESS2.C: The Roles of Water in Earth's Surface Processes

- 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 absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

AP BIology Science Practices:
Science Practice 1: Students can use representations and models to communicate scientific phenomena and solve scientific problems.
Science Practice 2: Students can use mathematics appropriately.
Science Practice 3: Students can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?* **Crosscutting Concepts**
1. What is the role of energy in the making and breaking of polymers? 2. How do living systems transmit information in order to ensure their survival? 3. How would living systems function without the polarity of the water molecule? 4. Is life as we know it possible without carbon? 5. What properties does water have that make it such a unique molecule?	**Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7) **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** ● Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2) ● Science assumes the universe is a vast single system in which the basics are consistent. (HS-ESS1-2) **Patterns** ● 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. (HS-LS4-1),(HS-LS4-3) **Scale, Proportion, and Quantity** ● The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1) ● Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2) **Energy and Matter** ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6) ● The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) **Structure and Function**

	● 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. (HS-LS1-1) **Cause and Effect** ● Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4) **AP BIOLOGY Enduring Understanding** **SY1** Living systems are organized in a hierarchy of structural levels that interact. **ENE1** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules. **1.D** The origin of living systems is explained by natural processes **2.A** Growth, reproduction and maintenance of the organization of living systems require free energy and matter. **4.A** Interactions within biological systems lead to complex properties **Essential Knowledge 1.D.1 There are several hypothesis about the natural origin of life on Earth, each with supporting scientific evidence.** ● Scientific Evidence supports various models. ○ Molecules served as monomers or building blocks for the formation of more complex molecules, including amino acids and nucleotides. ○ The joining of monomers produced polymers with the ability to replicate, store and transfer information. **Essential Knowledge 1.D.2 Scientific evidence from many different disciplines supports models of the origin of life.**

	● Scientific evidence includes molecular building blocks that are common to all life forms. ● Scientific evidence includes a common genetic code. **Essential Knowledge 2.A.1 All living systems require constant input of free energy.** ● Life requires a highly ordered system. ○ Increased disorder and entropy are offset by biological processes that maintain or increase order. ○ Order is maintained by constant free energy input into the system. ● Living systems do not violate the second law of thermodynamics, which states that entropy increases over time. ○ Order is maintained by coupling cellular processes that increase entropy with those that decrease entropy. ○ Energy input must exceed free energy lost to entropy to maintain order and power cellular processes. ○ Energetically favorable exergonic reactions, such as ATP -> ADP that have a negative change in free energy can be used to maintain or increase order in a system by being coupled with reactions that have a positive free energy change. **Essential Knowledge 2.A.3 Organisms must exchange matter with the environment to grow, reproduce and maintain organization.** ● Molecules and atoms from the environment are necessary to build new materials. ○ Carbon moves from the environment to organisms where it is used to build carbs, proteins, lipids, or nucleic acids. Carbon is used in storage compounds and

	cell formation in all organisms. ○ Nitrogen moves from the environment to organisms where it is used in building proteins and nucleic acids. Phosphorus moves from the environment to organisms where it is used in nucleic acids and certain lipids. ○ Living systems depend on properties of water that result from polarity and hydrogen bonding. ■ Adhesion ■ Cohesion ■ High specific heat capacity ■ Universal solvent supports reactions ■ Heat of vaporization ■ Heat of fusion ■ Water's thermal conductivity. **Essential Knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.** ● Structure and function of polymers are derived from the way their monomers are assembled. ● Directionality influences structure and function of the polymer. ○ Nucleic acids have ends, defined by 3' and 5' carbons of the sugar in the nucleotides… ○ Proteins have an amino end and a carboxyl end ○ The nature of the bonding between carbohydrate subunits determines their relative orientation in the carbohydrate, which then determines the secondary structure. **Essential Knowledge 4.B.1: Interactions between molecules affect their structure and function.**

	● Change in the structure of a molecular system may result in a change of the function of the system. ● The shape of enzymes, active sites and interactions with specific molecules are essential for basic functioning of the enzyme. ○ Complimentary substrate ○ Cofactors and coenzymes **Essential Knowledge 4.C.1: Variation in molecular units provides cells with a wider range of functions.** ● Variations within molecular classes provide cells and organisms with a wider range of functions. **Systems Interactions 1.B.1** Hydrolysis and dehydration synthesis are used to cleave and form covalent bonds between monomers. **ENERGETICS-1.A.1** Organisms must exchange matter with the environment to grow, reproduce, and maintain organization. **ENERGETICS-1.A.2** Atoms and molecules from the environment are necessary to build new molecules— ● Carbon is used to build biological molecules such as carbohydrates, proteins, lipids, and nucleic acids. Carbon is used in storage compounds and cell formation in all organisms. ● Nitrogen is used to build proteins and nucleic acids. Phosphorus is used to build nucleic acids and certain lipids.
Areas of Focus: Proficiencies (New Jersey Student Learning Standards)	**Lesson Possibilities**
Instructional Focuses 1. Identify and explain the significance of the various properties of water. 2. Differentiate between hydrolysis and dehydration reactions. 3. Classify the various macromolecules and their defining characteristics **Career-Ready Practices** **CRP1**: Act as a responsible and contributing citizen and employee. **CRP2**: Apply appropriate academic and	Review basic chemistry a. atomic structure b. Bonding basics c. chemistry of water Biochemistry basics POGIL #8 AP BIOLOGY Patterns matching doc and cards Macromolecules and their importance of carbon. a. Monomers vs polymers

technical skills. **CRP3**: Attend to personal health and financial well-being. **CRP4**: Communicate clearly and effectively and with reason. **CRP11**: Use technology to enhance productivity. **CRP12**: Work productively in teams while using cultural global competence.	b. Dehydration synthesis and hydrolysis. c. Virtual macromolecule lab https://wilmu.mediaspace.kaltura.com/media/Sci+251+-+Lab+Simulation+-+Biological+Macromolecules/0_ibkdoqzy d. Ideal food plan project e. 3-D molecular lab on amino acids and protein structure (can be used later on in gene expression as well).
Differentiation	**Assessments**
Connections ● Chemistry: bonding, van der waal forces, entropy, chemical reactions ● Environmental Science: water and its impact on the environment **Technology Integration Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology** ● Graphing software to plot reaction rates for enzyme lab. ● Titration **Media Literacy Integration** ● http://www.rcsb.org/pdb/home/home.do protein shapes ● https://concord.org/stem-resources/subject/biology various animations and activities with properties of water, amino acids and functional groups, conservation of energy, catalysts. **Global Perspectives** ● Utilization of NCBI global database	**Formative Assessments:** ● Various FRQ questions. ● Practice Albert and AP Biology assessments ● Chapter review. **Summative Assessments and Projects:** ● One minute reportsAtomic structure activity ● Pipe cleaner amino acid to protein. ● 3-D molecular characteristics of water ● Enzyme titration lab ● Properties of water station lab ● NCCSTS Case Studies.

Unit 2: Cell Structure and Function
11-13 Class periods 10-13% of AP exam
Chapters 6+7 in textbook

Next Generation Science Standards

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

AP Biology Big Idea

Big Idea 1: The process of evolution drives the diversity and unity of life.
Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
Big Idea 4. Biological systems interact, and these systems and their interactions possess complex properties.

Big Ideas:

Science and Engineering Practices.

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- **LS4-1** Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- **PS1-3** Plan and conduct an investigation individually and collaboratively to produce data to serve as 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.

Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- **PS1-4** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

NGSS Disciplinary Core Ideas

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)
- 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)

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
- 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. (HS-LS1-1)

- 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. (HS-LS1-2)
- 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. (HS-LS1-3)

LS1.C: Organization for Matter and Energy Flow in Organisms

- 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)
- 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 matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?* **Crosscutting Concepts**
1. What is the significance of form fitting function when it comes to cells? 2. How do the mechanisms for transport across membranes support energy conservation? 3. What are the advantages and disadvantages of cellular compartmentalization? 4. How are living systems affected by the presence or absence of subcellular components?	**Cause and Effect** ● Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4) **Patterns** ● 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. (HS-LS4-1),(HS-LS4-3) **Scale, Proportion, and Quantity** ● The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1) ● Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2) **Energy and Matter** ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5),

	(HS-LS1-6) **AP BIOLOGY Enduring Understanding** **1.B** Organisms are linked by lines of descent from common ancestry **2.A** Growth, reproduction and maintenance of the organization of living systems require free energy and matter. **2.B** Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments. **2.D** Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment ● **Essential Knowledge 1.B.1** Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. ● Structural evidence supports the relatedness of all eukaryotes ○ Cytoskeleton ○ Membrane-bound organelles ○ Chromosomes ○ Endomembrane system **Essential Knowledge 2.A.3** Organisms must exchange matter with the environment to grow, reproduce and maintain organization ● Surface area-to-volume ratios affect a biological system's ability to obtain necessary resources or eliminate waste products. ○ SA of plasma membrane must be large enough to adequately exchange materials; smaller cells have a more favorable SA:V ratio for exchange of materials with the environment **Essential Knowledge 2.B.1** Cell membranes are selectively permeable due to their structure ● Cell membranes separate internal from external environment. ● Selective permeability is due to membrane structure ○ Phospholipid bilayer, glycoproteins, cholesterol, protein channels

	○ Phospholipids give both hydrophilic and hydrophobic properties. ○ Embedded proteins can be hydrophilic with charged, polar side groups or hydrophobic due to nonpolar side groups ○ Small uncharged polar or nonpolar molecules freely pass membrane ● Cell wall provides a structural boundary and permeability barrier ○ Plant cell walls made of cellulose and outside membrane **Essential Knowledge 2.B.2** Growth and dynamic homeostasis are maintained by constant movement of molecules across membrane ● Passive transport moves from high concentration to low concentration ○ Facilitated diffusion ■ Glucose transport ■ NA^+/K^+ transport ○ Osmosis ○ External environments can be hypo/hyper/isotonic ● Active transport requires free energy to move molecules across a concentration gradient ○ ATP provides the energy needed ○ Membrane proteins are needed for active transport ● Endo and exocytosis move large molecules between internal and external environments **Essential Knowledge 2.B.3** Eukaryotes maintain internal membranes that partition the cell into specialized regions ● Help to facilitate cellular processes by minimizing competition interactions and increasing SA ● Localize intracellular metabolic processes and enzymatic reactions ○ ER ○ Mitochondria ○ Chloroplast ○ Golgi

	○ Nuclear envelope ● Archaea and bacteria lack internal membrane bound organelles
Areas of Focus: Proficiencies (Cumulative Progress Indicators)	**Lesson Possibilities**
Students will: ● Explain the significance of SA to V ratio in terms of metabolic pathways of cellular respiration and photosynthesis. ● Explain how the endomembrane system works to carry out functions ● Movement of molecules can occur freely without energy or with the use of energy. Explain these processes. ● Identify how the various macromolecules are important in the cell and membranes. ● Explain how form fits function in regards to cell membrane. **Career-Ready Practices** **CRP1**: Act as a responsible and contributing citizen and employee. **CRP2**: Apply appropriate academic and technical skills. **CRP4**: Communicate clearly and effectively and with reason. **CRP6**: Demonstrate creativity and innovation. **CRP7**: Employ valid and reliable research strategies. **CRP8**: Utilize critical thinking to make sense of problems and persevere in solving them. **CRP9**: Model integrity, ethical leadership and effective management. **CRP10**: Plan education and career paths aligned to personal goals. **CRP11**: Use technology to enhance productivity. **CRP12**: Work productively in teams while using cultural global competence.	1. Notes on cells: a. prokaryotic vs eukaryotic link to evolution and theories of endosymbiosis and infolding. b. Inquiry of Cell size SA:V inquiry lab followed by notes on importance of membranes and organelles in eukaryotic cells. 2. NCCSTS The story of where he came from for students to learn about important organelles. 3. Cell organelle disease project connect function to bigger picture of organism survival. 4. Microscope lab. 5. Cell membrane structure and function a. membrane bubble lab, transport. b. Water potential notes and water potential/osmosis lab (review molarity)

Differentiation	Assessments
Instructional Strategies/ Interdisciplinary Connections ● Chemistry **Technology Integration Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology** ● Various programs to create stop motion / time lapse animation of endomembrane system. **Media Literacy Integration** ● Cells alive ● Genetics Learning Center ● HHMI **Global Perspective**	**Formative Assessments:** ● Various FRQ questions. ● Practice Albert and AP Biology assessments ● Chapter review. **Summative Assessments:** ● One minute Reports ● Bubbles and cell membrane lab ● Surface area : volume challenge ● POGIL cell structure

Unit 3 Cellular Energetics

14-17 Class periods 12-16% of AP exam

Chapters 8-10 in textbook (with some connections to fitness in evolution chapter 23)

Next Generation Science Standards

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.

LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

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.

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

AP Biology Big Idea

Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

Big Idea 4. Biological systems interact, and these systems and their interactions possess complex properties.

Big Ideas:

Science and Engineering Practices.

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- **LS4-1** Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical,

and empirical models.

- **PS1-3** Plan and conduct an investigation individually and collaboratively to produce data to serve as 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.

Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- **PS1-4** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

NGSS Disciplinary Core Ideas

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)
- 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)

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
- 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. (HS-LS1-3)

LS1.C: Organization for Matter and Energy Flow in Organisms

- 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)
- 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 matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7)
- 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)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- 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 exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)

Essential Questions	Enduring Understandings

What provocative questions will foster inquiry, understanding, and transfer of learning?	*What will students understand about the big ideas?* **Crosscutting Concepts**
1. What is more important, cellular respiration or photosynthesis? 2. How are the first and second laws of thermodynamics applicable to the biology of a cell? 3. How is energy captured and then used by a living system? 4. How do organisms use energy or conserve energy to respond to environmental stimuli?	**Cause and Effect** ● Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4) **Patterns** ● 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. (HS-LS4-1),(HS-LS4-3) **Scale, Proportion, and Quantity** ● The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1) ● Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2) **Energy and Matter** ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6) **AP BIOLOGY Enduring Understanding** **Energetics:** The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules. ● **ENE-1.D.1** The structure of enzymes includes the active site that specifically interacts with substrate molecules. ● **ENE-1.D.2** For an enzyme-mediated chemical reaction to occur, the shape and charge of the substrate must be compatible with the active site of the enzyme. ● **ENE-1.E.1** The structure and function of enzymes contribute to the regulation of biological processes— a. Enzymes are biological catalysts that facilitate

	chemical reactions in cells by lowering the activation energy. **SYSTEM INTERACTIONS** Naturally occurring diversity among and between components within biological systems affects interactions with the environment. ● **SYI-3.A.1** Variation at the molecular level provides organisms with the ability to respond to a variety of environmental stimuli. ● **SYI-3.A.2** Variation in the number and types of molecules within cells provides organisms a greater ability to survive and/or reproduce in different environments. **Essential Knowledge 1.B.1** Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. ● Metabolic pathways are conserved across all currently recognized domains. **Essential Knowledge 2.A.1** All living systems require constant input of free energy ● Energy related pathways in biological systems are sequential and may be entered at multiple points in the pathway. ○ Krebs ○ Glycolysis ○ Calvin ○ Fermentation ● There is a relationship between metabolic rate per unit body mass and the size of multicellular organisms - generally, the smaller the organism, the higher metabolic rate. **Essential Knowledge 2.A.2** Organisms capture and store free energy for use in biological processes ● Autotrophs capture free energy from physical sources in the environment ○ Photosynthetic organisms capture free energy of sunlight ○ Chemoautotrophs capture free energy from inorganic molecules in absence of oxygen.

	● Heterotrophs capture free energy present in carbon compounds produced by other organisms. ○ Metabolism of carbs, lipids and proteins using hydrolysis ○ Fermentation produces organic molecules without oxygen ● Different energy capturing processes use different e^- acceptors ○ $NADP^+$ in photosynthesis ○ Oxygen in Cell resp ● The Light independent reaction of photosynthesis involves a series of coordinated reaction pathways. ○ Chlorophylls absorb energy from light in photosystems ○ PI and PII are embedded in internal membranes and connected by electron transfer ○ Electrochemical gradient of H^+created in ETC ○ Energy capture of light reaction fuels the production of carbs from CO_2 in Calvin Cycle ● Photosynthesis first evolved in prokaryotic organisms and was the foundation for eukaryotic pathways. ● Cellular respiration in eukaryotes involves a series of coordinated enzyme-catalyzed reactions that harvest free energy. ○ Glycolysis rearranges bonds in glucose to form ATP ○ Pyruvate is transferred from cytoplasm to mitochondria for oxidation ○ Krebs cycle releases CO_2,and ATP created ○ Krebs cycle removes electrons which are then carried to the ETC by NADH and $FADH_2$ ● ETC captures free energy from electrons in a series of coupled reactions creating an electrochemical gradient

	○ ETC in thylakoid in photosynthesis and mitochondria of cell resp ● Free energy becomes available for metabolism when ATP is converted to ADP
Areas of Focus: Proficiencies (Cumulative Progress Indicators)	**Lesson Possibilities**
Student will: ● Explain the significance of Surface Area to Volume ratio in terms of metabolic pathways of cellular respiration and photosynthesis. ● Differentiate between substrate level phosphorylation and chemiosmosis. ● Identify how the various macromolecules are important in the cell and membranes. **Career-Ready Practices** **CRP1**: Act as a responsible and contributing citizen and employee. **CRP2**: Apply appropriate academic and technical skills. **CRP4**: Communicate clearly and effectively and with reason. **CRP6**: Demonstrate creativity and innovation. **CRP7**: Employ valid and reliable research strategies. **CRP8**: Utilize critical thinking to make sense of problems and persevere in solving them. **CRP11**: Use technology to enhance productivity. **CRP12**: Work productively in teams while using cultural global competence.	1. Introduction to metabolism. a. anabolic and catabolic reactions. b. Metabolism and body size graphing / analysis 2. Proteins as enzyme catalysts. a. notes b. enzyme titration lab or equivalent. c. Enzymes and cell resp POGIL as transition to Cell resp. 3. Notes on cell resp, video resources and animations. a. importance of ATP b. exergonic vs endergonic c. aerobic vs anaerobic resp. d. substrate level vs oxidative phosphorylation phosphorylation (link to membrane structure and transport). 4. Activities / labs on Cell respiration a. pea / seed lab. b. POGIL Cell Resp 5. Notes on photosynthesis, visual animations, connections and videos. a. GIZMO (few different to choose from as previously used glencoe lab is no longer supported by flash) b. Cyclic vs noncyclic Photosynthesis with a link to evolution.
Differentiation	**Assessments**

Instructional Strategies/ Interdisciplinary Connections ● Chemistry **Technology Integration Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology** ● Create visual representations of pathways addressing where specific steps and actions are occurring. ● GIZMOS cell respiration stem case ● Virtual photosynthesis lab **Media Literacy Integration** ● Cells alive ● Genetics Learning Center ● HHMI **Global Perspective** ● Comparison of rates of reaction in varying locations across globe in various climates, differing conditions	Formative Assessment: ● Practice FRQ ● Albert Quiz ● AP practice quies Summative Assessment: ● One minute report ● POGILS

Unit 4 Cell Communication and Cell Cycle

9-11 Class periods 10-15% of AP exam

Focused Chapter 11

Additional chapters to reference: Immune Ch. 43, Osmoregulation Ch 44, Endocrine Ch 45 and Nervous system Ch 48 and 49

Next Generation Science Standards
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. **LS1-4** Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. **ESS2- 7.** Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.
AP Biology Big Idea
Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis. **Big Idea 3:** Living systems store, retrieve, transmit and respond to information essential to life processes.
Big Ideas:

Science and Engineering Practices.

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- **LS4-1** Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- **PS1-3** Plan and conduct an investigation individually and collaboratively to produce data to serve as 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.

Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- **PS1-4** Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

NGSS Disciplinary Core Ideas

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
- 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. (HS-LS1-1)
- 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. (HS-LS1-2)
- 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. (HS-LS1-3)

LS1.B: Growth and Development of Organisms

- In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?* **Crosscutting Concepts**
	Cause and Effect

1. How is energy used in cellular communication? 2. How does the cell cycle aid in the conservation of genetic information? 3. Why and in what ways do cells communicate with one another? 4. In what ways is the cell cycle regulated? 5. How do the principles of cell-to-cell communication relate to the functioning of organ systems, especially the immune, endocrine, and nervous systems? 6. How are signal transduction pathways involved in cellular responses in plants and animals?	● Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4) **Patterns** ● 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. (HS-LS4-1),(HS-LS4-3) **Scale, Proportion, and Quantity** ● The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1) ● Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2) **Energy and Matter** ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6) ● ● **IST-3** Cells communicate by generating, transmitting, receiving, and responding to chemical signals. ● **ENE-3** Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues. ● **IST-1** Heritable information provides for continuity of life. **Essential Knowledge 2.D.1** All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy ● Cell activities are affected by interactions with biotic and abiotic factors ○ Cell density

	○ Biofilms ○ Temperature ○ Water availability ○ sunlight **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. ● Cell cycle is complex which is regulated by checkpoints ○ Interphase ■ Growth, synthesis and preparation for division ○ Internal controls provide stop and go signals ■ Mitosis promoting factor ■ Platelet derived GF ■ Disruption of cycle and cancer ○ Cyclins and CDK control cycle ○ Mitosis and interphase alternate ● Mitosis passes a complete genome from the parent cell to daughter cell ● Meiosis is a reduction division followed by fertilization ensures genetic diversity in sexually reproducing organisms ● Fertilization involves the fusion of 2 gametes and increases genetic variation a population **Essential Knowledge 3.D.1** Cell communication processes share common features that reflect a shared evolutionary history. ● Communication involves transduction of stimulatory or inhibitory signals from other cells, organisms or the environment ● Correct and appropriate signal transduction processes are generally under strong selective pressure. ● Single celled organisms and signal transduction ○ Influence cell response to environment.

	■ Pheromones ■ Microbe chemical messages ■ movement ● Multicellular organisms and signal transduction ○ coordinate activities of individual cells to function as whole **Essential Knowledge 3.D.2** Cell communication with each other through direct contact with other cells or from a distance via chemical signaling. (*ALL BELOW ARE NOW CONSIDERED INSTRUCTIONAL EXAMPLES AND NOT ALL NEEDED TO BE ADDRESSED)* ● Cell to cell contact ○ Immune system (helper T and killer T cells) ○ Plasmodesmata in plants ● Local regulators for short distance cell communication ○ Neurotransmitters ○ Plant immune response ○ Quorum sensing in bacteria ○ Morphogens in embryos ● Long distance cell signaling ○ Endocrine system **Essential Knowledge 3.D.3** SIgnal Transduction pathways link signal reception with cellular response. ● Ligands and receptor proteins ● Signal transduction converts signal to cellular response **Essential Knowledge 3.D.4** Changes in signal transduction pathways can alter cellular response ● Blockage of pathways ○ Diabetes ○ Neurotoxins ○ drugs **AP BIOLOGY ESSENTIAL KNOWLEDGE** **IST-3.A.1** Cells communicate with one another through direct contact with other cells or from a distance via chemical signaling— A. Cells communicate by cell-to-cell contact.

	IST-3.B.1 Cells communicate over short distances by using local regulators that target cells in the vicinity of the signal-emitting cell— A. Signals released by one cell type can travel long distances to target cells of another cell type. **IST-3.D.1** Signaling begins with the recognition of a chemical messenger—a ligand—by a receptor protein in a target cell— A. The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide, a small chemical, or protein, in a specific one-to-one relationship. B. G protein-coupled receptors are an example of a receptor protein in eukaryotes. **IST-3.D.2** Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, resulting in the appropriate responses by the cell, which could include cell growth, secretion of molecules, or gene expression— A. After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal. B. Second messengers (such as cyclic AMP) are molecules that relay and amplify the intracellular signal. C. Binding of ligand-to-ligand-gated channels can cause the channel to open or close. **IST-3.E.1** Signal transduction pathways influence how the cell responds to its environment. **IST-3.F.1** Signal transduction may result in changes in gene expression and cell function, which may alter phenotype or result in programmed cell death (apoptosis). **IST-3.G.1** Changes in signal transduction pathways can alter cellular response— A. Mutations in any domain of the receptor protein or in any component of the signaling pathway may affect the downstream components by altering the

	subsequent transduction of the signal. **IST-3.G.2** Chemicals that interfere with any component of the signaling pathway may activate or inhibit the pathway
Areas of Focus: Proficiencies (Cumulative Progress Indicators)	**Lesson Possibilities**
Instructional Focus: ● Movement of molecules can occur freely without energy or with the use of energy. Explain these processes. ● Cell cycle is controlled by various checkpoints. ● Differentiate between different methods of cell signaling ● Demonstrate understanding of both positive and negative feedback mechanisms and when each would be appropriate. **Career-Ready Practices** **CRP1**: Act as a responsible and contributing citizen and employee. **CRP2**: Apply appropriate academic and technical skills. **CRP3**: Attend to personal health and financial well-being. **CRP4**: Communicate clearly and effectively and with reason. **CRP5**: Consider the environmental, social and economic impacts of decisions. **CRP6**: Demonstrate creativity and innovation. **CRP7**: Employ valid and reliable research strategies. **CRP8**: Utilize critical thinking to make sense of problems and persevere in solving them. **CRP9**: Model integrity, ethical leadership and effective management. **CRP10**: Plan education and career paths aligned to personal goals. **CRP11**: Use technology to enhance productivity.	● Intro to cell communication linking cell membrane structure/function and transport. a. Notes and POGIL Cell communication b. How cells communicate c. Stop motion video on signal transduction pathways d. NCCSTS Case study: My dog is broken or diabetes and insulin signalling ● Infographic: When things go wrong and faulty cell communication project. ● Notes on the cell cycle / mitosis. a. mitosis microscope lab b. Mitosis POGIL ● Cell cycle regulation and cancer a. HHMI Cancer and cell cycle activity : ● Simulation of G protein and Tyrosine Kinase receptor pathways ● Endomembrane system activity ● AP Bio Resources: Cell communication ● Illustrated Examples: ○ Neuron communication model activity. ○ Immune system and cellular responses **Assessments** **Formative Assessments:** ● Various FRQ questions. ● Practice Albert and AP Biology assessments ● Chapter review.

CRP12: Work productively in teams while using cultural global competence.	**Summative Assessments:** ● One minute report ● Exit tickets on signal transduction ● Neon marker group demonstration of signal cascade. ●
Differentiation	
Instructional Strategies/ Interdisciplinary Connections ● Chemistry ● anatomy and physiology ● exercise science **Technology Integration Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology** ● Various programs to create stop motion / time lapse animation of pathways **Media Literacy Integration** ● Cells alive ● Genetics Learning Center ● HHMI **Global Perspective** ● Current research in medicine or global approaches to prevent or treat infectious disease at the cellular level. (WHO, CDC, etc)	

Unit 5: Heredity

9-11 Class periods 8-11% of AP exam

Chapters 13-16 in textbook

Next Generation Science Standards

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.

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

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.

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

LS3-3 Apply concepts of statistics and probability to explain the variation and distribution

of expressed traits in a population.

AP Biology Big Idea

Big Idea 1: The process of evolution drives the diversity and unity of life.
Big Idea 3 Living systems store, retrieve, transmit and respond to information essential to life processes.
Big Idea 4. Biological systems interact, and these systems and their interactions possess complex properties.

Big Ideas:

Asking Questions and Defining Problems Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- **LS3-1** Ask questions that arise from examining models or a theory to clarify relationships.

Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- **LS1-4** Use a model based on evidence to illustrate the relationships between systems or between components of a system.

Analyzing and Interpreting Data
Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze
data.

- **LS3-3** 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 problems, using digital tools when feasible.

Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- **LS3-2** Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.

NGSS Disciplinary Core Ideas

LS1.A Structure and Function

- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins.

LS1.B: Growth and Development of Organisms

- In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4)

LS3.A: Inheritance of Traits

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)

LS3.B: Variation of Traits

- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)
- 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. (HS-LS3-2),(HS-LS3-3)

AP BIology Science Practices:

Science Practice 2: The student can use mathematics appropriately.

Science Practice 7 The student is able to connect and relate knowledge across various scales, concepts and representations in and across domains.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?* **Crosscutting Concepts**
1. How are the processes of mitosis and meiosis involved in the transmission of genetic information? 2. Beyond simple Mendelian genetics, what patterns of inheritance can explain the transmission of certain traits? - How would Mendel's laws have been affected if he had studied a different type of plant? 3. What mechanisms are involved in maintaining variation in sexually reproducing species? 4. How have scientists clarified the structure and mechanisms of molecular inheritance? 5. What is the relationship between evolution influenced and genetics? 6. Is it important that not all inherited characteristics get expressed in the next generation?	Students will understand: **Cause and Effect** - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1),(HS-LS3-2) **Scale, Proportion, and Quantity** - 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). (HS- LS3-3) **Systems and System Models** - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS1-4) **Connections to Nature of Science** **Science is a Human Endeavor**

7. How does the diversity of a species affect inheritance? 8. How can the same genotype result in multiple phenotypes under different environmental conditions	● Technological advances have influenced the progress of science and science has influenced advances in technology. (HS-LS3-3) ● Science and engineering are influenced by society and society is influenced by science and engineering. (HS-LS3-3) **AP BIOLOGY Enduring Understanding** **SYI-3** Naturally occurring diversity among and between components within biological systems affects interactions with the environment. ● **SYI-3.C.1** Segregation, independent assortment of chromosomes, and fertilization result in genetic variation in populations. ● **SYI-3.C.2** The chromosomal basis of inheritance provides an understanding of the pattern of transmission of genes from parent to offspring. ● **SYI-3.C.3** Certain human genetic disorders can be attributed to the inheritance of a single affected or mutated allele or specific chromosomal changes, such as nondisjunction. **Essential Knowledge 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 ● Observable cell differentiation results from the expression of genes for tissue-specific proteins. ● Induction of transcription factors during development results in sequential gene expression. ● Apoptosis plays a role in the normal development and differentiation. **Essential Knowledge 3.A.1** DNA, and in some cases RNA, is the primary source of heritable information ● Genetic information is transmitted from one generation to the next through DNA or RNA

	● Non Eukaryotes have circular chromosomes and eukaryotes have linear ● Replication of DNA ensures continuity of hereditary information ○ Semiconservative **Essential Knowledge 3.A.3** The chromosomal basis of inheritance provides an understanding of the pattern of passage of genes from parents to offspring ● Rules of probability ● Segregation and independent assortment of chromosomes result in genetic variation ● Certain human genetic disorders can be attributed to the inheritance of single gene traits or specific chromosomal changes such as nondisjunction ○ Sickle cell anemia ○ Tay-Sachs ○ Huntington's disease ○ X-linked color blindness ○ Trisomy 21 ○ Klinefelter's syndrome ● Ethical, social and medical issues and genetic disorders **Essential Knowledge 3.A.4** The inheritance pattern of many trait cannot be explained by simple Mendelian genetics ● Multigene or physiological processes ● Sex chromosome genes ● Nonnuclear inheritance ○ Mitochondrial DNA from egg **Essential Knowledge 3.C.1** Changes in genotype can result in changes in phenotype ● Alterations in DNA sequence can lead to changes in the type or amount of protein produced ○ DNA mutations can be positive, negative or neutral ● Errors in DNA replication or DNA repair mechanisms ● Errors in mitosis or meiosis can result in changes in phenotype

	Essential Knowledge 3.C.2 Biological systems have multiple processes that increase genetic variation ● Imperfect nature of DNA replication and repair increase variation ● Horizontal gene transfer ● Sexual reproduction in eukaryotes involving gamete formation, independent assortment, crossing over etc. **Essential Knowledge 3.C.3** Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts
Areas of Focus: Proficiencies (New Jersey Student Learning Standards)	**Lesson Possibilities**
Students will: ● Differentiate between mitosis and meiosis. ● Identify the various mechanisms of inheritance ● Demonstrate understanding of probability by correctly utilizing chi squared. **Career-Ready Practices** **CRP1**: Act as a responsible and contributing citizen and employee. **CRP2**: Apply appropriate academic and technical skills. **CRP3**: Attend to personal health and financial well-being. **CRP4**: Communicate clearly and effectively and with reason.. **CRP8**: Utilize critical thinking to make sense of problems and persevere in solving them. **CRP11**: Use technology to enhance productivity. **CRP12**: Work productively in teams while using cultural global competence.	1. Introduction to reproduction comparison: Sexual vs asexual. Evolutionary advantage to each. 2. Group work brainstorming: How does Meiosis increase genetic variation? a. random fertilization b. crossing over c. independent assortment 3. Mendelian genetics a. intro inheritance lab b. notes Dominant and recessive inheritance c. Laws of probability notes and activities (POGIL or Penny Lab) d. Punnet Squares i. mono/dihybrid 4. Non Mendelian genetics a. Intermediate inheritance b. Codominance c. Sex linked 5. Chromosomal inheritance a. gene loci b. crossing over vs genetic linkage c. epistasis 6. Tools of inheritance and genetic counselors a. chi square analysis b. pedigrees

	c. chromosomal disorders or characteristics ○ Fruit fly virtual lab and chi squared analysis ○ Meiosis animation ○ crossing over demonstration and genetic linkage analysis ○ Sickle cell disorder and heterozygote advantage
Differentiation	**Assessments**
Instructional Strategies/ Interdisciplinary Connections ● Chemistry ● Physics: Law of thermodynamics, Law of conservation of energy, Law of conservation of matter **Technology Integration Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology** ● HHMI website simulations and animations ● Gizmos inheritance lab **Media Literacy Integration** ● See above technology **Global Perspectives** ● Global databases for known DNA and Gene sequences ● Human Genome Project	**Formative Assessments:** ● Math grid in relating to chi squared ● Inheritance patterns and genetics probability. ● Various modified FRQ **Summative Assessments:** ● Exit ticket on punnet squares. ● One minute report. ● CER

Unit 6: Gene Expression and Regulation

18-21 Class periods 12-16% of AP exam

Chapters 17-21 in textbook

Next Generation Science Standards
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. **LS1-4** Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. **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. **LS3-2** Make and defend a claim based on evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors during replication, and/or mutations caused by environmental factors.

LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

AP Biology Big Idea

Big Idea 3 Living systems store, retrieve, transmit and respond to information essential to life processes.

Big Ideas:

Asking Questions and Defining Problems Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- **LS3-1** Ask questions that arise from examining models or a theory to clarify relationships.

Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- **LS1-4** Use a model based on evidence to illustrate the relationships between systems or between components of a system.

Analyzing and Interpreting Data

Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze
data.

- **LS3-3** 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 problems, using digital tools when feasible.

Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- **LS3-2** Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.

AP BIology Science Practices:

Science Practice 2: Student can use mathematics appropriately.

Science Practice 7 The student is able to connect and relate knowledge across various scales, concepts and representations in and across domains.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?* **Crosscutting Concepts**
1. How does gene regulation relate to the continuity of life? 2. How is a species' genetic information diversified from generation to generation?	Students will understand: **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1),(HS-LS3-2) **Scale, Proportion, and Quantity** ● 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). (HS- LS3-3) **Systems and System Models** ● Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-LS1-4) **Connections to Nature of Science** **Science is a Human Endeavor** ● Technological advances have influenced the progress of science and science has influenced advances in technology. (HS-LS3-3) ● Science and engineering are influenced by society and society is influenced by science and engineering. (HS-LS3-3) **AP BIOLOGY Enduring Understanding** **2.C** Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis **2.E** Many biological processes involved in growth, reproduction and dynamic homeostasis include tem poral regulation and coordination **3.A** Heritable information provides for continuity of life **3.B** Expression of genetic info involves cellular and molecular mechanisms. **3.C** The processing genetic information is imperfect and is a source of genetic variation **Essential Knowledge 2.C.1** Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental change ● Operons in gene regulation **Essential Knowledge 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

	● Observable cell differentiation results from the expression of genes for tissue-specific proteins. ● Induction of transcription factors during development results in sequential gene expression. **Essential Knowledge 3.A.1** DNA, and in some cases RNA, is the primary source of heritable information ● Genetic information is transmitted from one generation to the next through DNA or RNA ● Non Eukaryotes have circular chromosomes and eukaryotes have linear ● Proof of DNA as the genetic info ○ Watson, Crick, Wilkins, Franklin and DNA structure ○ Avery-MacLeod-McCarty experiments ○ Hershey-Chase experiment ● Replication of DNA ensures continuity of hereditary information ○ Semiconservative ○ DNA polymerase and other enzymes ● The DNA strand acting as the template strand is also referred to as the noncoding strand, minus strand, or antisense strand. Selection of which DNA strand serves as the template strand depends on the gene being transcribed. ● In eukaryotic cells the mRNA transcript undergoes a series of enzyme-regulated modifications— ○ Addition of a poly-A tail. ○ Addition of a GTP cap. ○ Excision of introns and splicing and retention of exons. ○ Excision of introns and splicing and retention of exons can generate different versions of the resulting mRNA molecule; this is known as alternative splicing. ● Retroviruses use RNA to DNA mechanism

	● Similarities in DNA and RNA structures and differences that define function ○ Sugar, phosphate, nitrogen base, 3' and 5' ends ○ Differences Deoxyribose vs ribose, thymine vs uracil, double strand vs single strand ● Conserved Base pairing ○ Purine (G and A) bind to pyrimidines (C, T, U) ● Sequence of bases determines function ○ mRNA brings DNA to ribosome ○ tRNA binds specific amino acids ○ rRNA building blocks of ribosomes ○ RNAi helps with regulation of gene expression at level of mRNA transcription ● Genetic information flows from a sequence of nucleotides in a gene to a sequence of amino acids in a protein. ○ RNA polymerase reads DNA molecules in the 3' to 5' end ○ mRNA transcript undergoes series of enzyme-regulated modifications ■ Addition of poly-A tail, GTP cap, excision of introns ○ Translation of mRNA occurs on ribosomes in cytoplasm ○ Prokaryotes have transcription coupled to translation, using energy, initiation, elongation and termination ● Regulatory sequences are stretches of DNA that interact with regulatory proteins to control transcription.

	● Epigenetic changes can affect gene expression through reversible modifications of DNA or histones. ● The phenotype of a cell or organism is determined by the combination of genes that are expressed and the levels at which they are expressed ○ Observable cell differentiation results from the expression of genes for tissue specific proteins. ○ Induction of transcription factors during development results in sequential gene expression. ● Both prokaryotes and eukaryotes have groups of genes that are coordinately regulated ○ In prokaryotes, groups of genes called operons are transcribed in a single mRNA molecule. The lac operon is an example of an inducible system. ○ In eukaryotes, groups of genes may be influenced by the same transcription factors to coordinately regulate expression. ● Genetic engineering techniques can manipulate the heritable information of DNA and RNA ○ Electrophoresis ○ Plasmid-based transformation ○ Restriction enzyme analysis of DNA ○ PCR ● Genetic Engineering products ○ Genetically Modified foods ○ Transgenic organisms ○ Cloned animals ○ pharmaceuticals **Essential Knowledge 3.B.1** Gene regulation results in differential gene expression, leading to cell specialization ● DNA regulatory sequences and regulatory genes and small regulatory RNA are involved in gene expression

	○ Promoters ○ Terminators ○ Enhancers ● Both positive and negative control mechanisms regulate gene expression in bacteria and viruses ○ Inducers turn on gene expression ○ Repressors inhibit gene expression ○ Inducers and repressors are molecules that interact with regulatory proteins ○ Regulatory proteins inhibit gene expression by binding to DNA and blocking transcription (NEGATIVE CONTROL) ○ Regulatory proteins stimulate gene expression by binding to DNA and stimulating transcription (POSITIVE CONTROL) or binding to repressor and inactivating it ○ Some genes are continuously expressed ● Gene expression in eukaryotes is complex ● Gene regulation accounts for some of the phenotypic differences between organisms with similar genes **Essential Knowledge 3.B.2** A variety of intercellular and intracellular signal transmission mediate gene expression. ● Cytokines regulate expression ○ cAMP levels in bacteria ● Signal transduction within and between cells mediates cell function **Essential Knowledge 3.C.1** Changes in genotype can result in changes in phenotype ● Alterations in DNA sequence can lead to changes in the type or amount of protein produced ○ DNA mutations can be positive, negative or neutral ● Errors in DNA replication or DNA repair mechanisms, and external

	factors, including radiation and reactive chemicals, can cause random mutations in the DNA ○ Whether a mutation is detrimental, beneficial, or neutral depends on the environmental context. ○ Mutations are the primary source of genetic variation. ● Errors in mitosis or meiosis can result in changes in phenotype ○ Changes in chromosome number often result in new phenotypes, including sterility caused by triploidy, and increased vigor of other polyploids. ○ Changes in chromosome number often result in human disorders with developmental limitations, including Down syndrome/ Trisomy 21 and Turner syndrome.
Areas of Focus: Proficiencies (New Jersey Student Learning Standards)	**Lesson Possibilities**
Students will: ● Describe the structures involved in passing hereditary information from one generation to the next. ● Describe the characteristics of DNA that allow it to be used as the hereditary material. ● Describe the mechanisms by which genetic information *is copied* for transmission between generations. ● Describe the mechanisms by which genetic information *flows* from DNA to RNA to protein. ● Explain how the phenotype of an organism is determined by its genotype. ● Describe the types of interactions that regulate gene expression. ● Explain the connection between the regulation of gene expression and phenotypic differences in cells and organisms.	1. Group brainstorm. What is the significance of DNA and RNA? How do they link to the previous unit of heredity? 2. Notes on structure of DNA and RNA (link back to chemistry, importance of the specific bonds/forces) a. HHMI animations b. Videos c. Worksheets on structure 3. Timeline of DNA activity 4. Notes on DNA replication a. direction of DNA b. base pairing c. use of enzymes: helicase, polymerase, topoisomerase, ligase d. semiconservative 5. The creation of RNA: transcription. a. notes and worksheets 6. RNA to protein: Translation. 7. How gene expression is regulated.

<table>
<tr>
<td>

- Describe the various types of mutation.
- Explain how changes in genotype may result in changes in phenotype
- Explain how alterations in DNA sequences contribute to variation that can be subject to natural selection
- Explain the use of genetic engineering techniques in analyzing or manipulating DNA.

Career-Ready Practices
CRP1: Act as a responsible and contributing citizen and employee.
CRP2: Apply appropriate academic and technical skills.
CRP4: Communicate clearly and effectively and with reason.
CRP5: Consider the environmental, social and economic impacts of decisions.
CRP6: Demonstrate creativity and innovation.
CRP7: Employ valid and reliable research strategies.
CRP8: Utilize critical thinking to make sense of problems and persevere in solving them.
CRP11: Use technology to enhance productivity.
CRP12: Work productively in teams while using cultural global competence.

</td>
<td>

8. Mutations and how they impact gene expression.
    - Mutations in the CFTR gene disrupt ion transport and result in cystic fibrosis.
    - Mutations in the MC1R gene give adaptive melanism in pocket mice. (HHMI activity)

9. Biotechnology
    a. PGlo lab
    b. DNA gel electrophoresis (lab or GIZMO)
    c. genetic engineering Visual-PSA

</td>
</tr>
<tr>
<th>Differentiation</th>
<th>Assessments</th>
</tr>
<tr>
<td>

Instructional Strategies/ Interdisciplinary Connections

- Chemistry
- Physics: Law of thermodynamics, Law of conservation of energy, Law of conservation of matter

Technology Integration Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology

</td>
<td>

Formative Assessments:

- Various modified FRQ
- Albert questions
- Goformative assessment

Summative assessments / Projects

- CER impact of mutations
- One minute report
- exit ticket of daily topic
- genetic engineering Visual-PSA

</td>
</tr>
</table>

• Biotechnology • HHMI website simulations and animations • NCBI DNA databases **Media Literacy Integration** • See above technology **Global Perspectives** • Global databases for known DNA and Gene sequences • Human Genome Project	

Unit 7: Natural Selection

20-23 Class periods 13-20% of AP exam

Focused Chapters 22-26 in textbook

Additional chapters 27-34 (Diversity of life)

Next Generation Science Standards **LS4-1** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. **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. **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. **LS4-4** Construct an explanation based on evidence for how natural selection leads to adaptation of populations. **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. **AP Biology Big Idea** **Big Idea 1:** The process of evolution drives the diversity and unity of life. **Big Idea 4.** Biological systems interact, and these systems and their interactions possess complex properties.
Big Ideas: **Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • 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 problems, using digital tools when feasible. (HS-LS4-3)

Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- 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),(HS-LS4-4)

Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come
from current or historical episodes in science.

- Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS4-5)

Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-LS4-1)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-LS4-1)

NGSS Disciplinary Core Ideas

LS4.A: Evidence of Common Ancestry and Diversity

- Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1)

LS4.B: Natural Selection

- Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2),(HS-LS4-3)
- The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)

LS4.C: Adaptation

- Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)
- Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not (HS-LS4-3),(HS-LS4-4)
- Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-5)
- Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5)

AP BIology Science Practices:
Science Practice 2: Student can use mathematics appropriately.
Science Practice 5 The student can perform data analysis and evaluation of evidence.
Science Practice 6 The student can work with scientific explanations and theories.
Science Practice 7 The student is able to connect and relate knowledge across various scales, concepts and representations in and across domains.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?* **Crosscutting Concepts**
1. How can evolution explain the rich diversity of life on the planet? 2. What mechanisms can lead to evolutionary change in a population, and, ultimately, the evolution of a new species? 3. How can evolutionary relationships and the development of bioinformatics be used to classify organisms? 4. What conditions in a population make it more or less likely to evolve? Scientifically defend the theory of evolution. 5. How does species interaction encourage or slow changes in species?	Students will understand: **Patterns:** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for phenomena. (HS-LS4-1),(HS-LS4-3) **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-2),(HS-LS4-4),(HS-LS4-5) **AP BIOLOGY Enduring Understanding** **1.A** Change in the genetic makeup of a population over time is evolution.

	1.B Organisms are linked by lines of descent from common ancestry. **1.C** Life continues to evolve within a changing environment **1.D** The origin of living systems is explained by natural processes **Essential Knowledge 1.A.1** Natural selection is a major mechanism of evolution ● According to Darwin competition for limited resources results in differential survival. Those with more favorable phenotypes are more likely to pass on traits. ● Fitness is measured by reproductive success. ● Genetic variation and mutation play roles in natural selection ● Environments can impact evolutionary rate and direction. ● Adaptations are genetic variations favored by selection. ● Chance and random events influence evolution. ● Hardy-weinberg equilibrium needs large population, absence of migration, no net mutations, random mating, absence of selection. **Essential Knowledge 1.A.2** Natural selection acts on phenotypic variations in a populations. ● Environments change and act as selective mechanisms. ○ Peppered moths ● Phenotypic variations are not directed by environment, but occur through random changes of DNA or new genes. ● Some phenotypes significantly increase or decrease fitness. ○ Sickle cell anemia ○ DDT resistance ○ Peppered moths ● Humans impact variation in other species. ○ Artificial selection ○ Loss of genetic diversity ○ Antibiotic overuse

	Essential Knowledge 1.A.3 Evolutionary change is also driven by random processes. ● Genetic drift is a nonselective process occurring in small populations ● Reduction of genetic variation within a given population can increase the differences between populations of the same species. **Essential Knowledge 1.A.4** Biological evolution is supported by scientific evidence from many disciplines, including math ● Fossil dating and half life ● Biochemical and genetic similarities ● Mathematical models and simulations ○ Graphical analysis of allele frequencies in a population ○ Analysis of sequence data sets ○ Analysis of phylogenetic trees ○ Construction of phylogenetic trees based on sequence data **Essential Knowledge 1.B.1** Organisms share many conserved processes and features that evolved and are widely distributed among organisms today. ● Structural and functional evidence ○ DNA and RNA are carriers of genetic information ○ Major features of genetic code are shared ○ Metabolic pathways are conserved. **Essential Knowledge 1.B.2** Phylogenetic trees and cladograms are graphical representations of evolutionary history that can be tested. ● Represent traits that are derived or lost due to evolution. ○ Number of heart chambers ○ Opposable thumbs ○ Absence of legs ● Illustrate speciation that has occurred, in that relatedness of any two groups on the tree is shown by

	how recently two groups had a common ancestor. ● Can be constructed from morphological similarities, from DNA and protein sequence similarities, computer programs. ● They are dynamic based on the biological data used. **Essential Knowledge 1.C.1** Speciation and extinction have occurred throughout Earth's history ● Speciation rates can vary especially when adaptive radiation occurs. ● Species extinction rates are rapid at times of ecological stress ○ 5 major extinctions ○ Human impact on ecosystems and species extinction rates **Essential Knowledge 1.C.2** Speciation may occur when two populations become reproductively isolated from each other. ● Speciation results in diversity of life due to ○ Geographic barriers, pre and post zygotic mechanisms. **Essential Knowledge 1.C.3** Populations of organisms continue to evolve ● Chemical resistance ● Emergent diseases ● Directional phenotypic change
Areas of Focus: Proficiencies (Cumulative Progress Indicators)	**Lesson Possibilities**
Students will ● Describe the causes of natural selection. ● Explain how natural selection affects populations. ● Describe the importance of phenotypic variation in a population. ● Explain how humans can affect diversity within a population. ● Explain the relationship between changes in the environment and evolutionary changes in the population.\	● Chapter opener/ group discussion: What is natural selection? How is evolution connected to all of the topics we've discussed so far? ● Notes on requirements for natural selection (and evolution) to occur. ○ How does heredity come into play? ○ Why is variation essential? ○ How can humans manipulate the process? ● Population genetics notes and activity ○ Gene pool and allele frequency.

● Explain how random occurrences affect the genetic makeup of a population. ● Describe the role of random processes in the evolution of specific populations. ● Describe the change in the genetic makeup of a population over time. ● Describe the conditions under which allele and genotype frequencies will change in populations. ● Explain the impacts on the population if any of the conditions of HardyWeinberg are not met. ● Describe the types of data that provide evidence for evolution. ● Explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time. ● Describe the fundamental molecular and cellular features shared across all domains of life, which provide evidence of common ancestry. ● Describe structural and functional evidence on cellular and molecular levels that provides evidence for the common ancestry of all eukaryotes. ● Explain how evolution is an ongoing process in all living organisms. ● Describe the types of evidence that can be used to infer an evolutionary relationship ● Explain how a phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness. ● Describe the conditions under which new species may arise. ● Describe the rate of evolution and speciation under different ecological conditions. ● Explain the processes and mechanisms that drive speciation. ● Describe factors that lead to the extinction of a population.	○ Math calculations of how the gene pool can change over multiple generations. ○ Rock pocket mouse HHMI activity ○ How genetic drift impacts gene pool. ● Are populations ever not evolving? Hardy Weinberg Equilibrium. ○ What are the conditions for HWE and what happens if any one of the conditions is not met? ○ Hardy Weinberg POGIL and/or goldfish lab ● Notes on Macroevoltuion: What evidence exists of evolution on large scale? ○ Fossil evidence ■ convergent and divergent evolution ○ DNA analysis ○ speciation and extinction ● Phylogeny and how scientists attempt to sort, group and make connections. ○ HHMI and various activities ○ Blast search and DNA analysis to create trees. ○ Analyzing phylogenetic trees. ● Where did it all begin? How did life on earth start? ○ CER and group discussions. ○ Video clips ○ link back to previous units ○ Expand into classification.

• Explain how the risk of extinction is affected by changes in the environment • Explain species diversity in an ecosystem as a function of speciation and extinction rates. • Explain how extinction can make new environments available for adaptive radiation. • Explain how the genetic diversity of a species or population affects its ability to withstand environmental pressures. • Describe the scientific evidence that provides support for models of the origin of life on Earth. **Career-Ready Practices** **CRP1**: Act as a responsible and contributing citizen and employee. **CRP2**: Apply appropriate academic and technical skills. **CRP4**: Communicate clearly and effectively and with reason. **CRP7**: Employ valid and reliable research strategies. **CRP8**: Utilize critical thinking to make sense of problems and persevere in solving them. **CRP11**: Use technology to enhance productivity. **CRP12**: Work productively in teams while using cultural global competence.	
Differentiation	**Assessments**
Technology Integration Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology • HHMI Beak of the Finch video and activity • HHMI phylogenetic comparison • NCBI database • Time lapse videos **Media Literacy Integration**	**Formative Assessment:** • FRQs • Albert quizzes • Chapter reviews • AP practice based exams **Summative Assessments and project.** • Time lapse of genetic drift • AP Bio Special Focus: Evolution • Exit tickets math problems.

● See above technology **Global Perspectives** ● Global databases for known DNA and Gene sequences and comparisons with phylogenetic trees.	● Phylogenetic trees and cladograms using hhmi and NCBI ● Geologic timescale

Unit 8: Ecology

18-21 Class periods 10-15% of AP exam

Chapters 52-56 in textbook

Next Generation Science Standards

LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect K of ecosystems at different scales.
LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different niches
LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
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.

AP Biology Big Idea

Big Idea 1: The process of evolution drives the diversity and unity of life.
Big Idea 2. Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
Big Idea 3. Living systems store, retrieve, transmit and respond to information essential to life processes.
Big Idea 4. Biological systems interact, and these systems and their interactions possess complex properties.

Big Ideas:
Science and Engineering Practices.
Using Mathematical and Computational Thinking

Mathematical and Computational Thinking at the 9–12 level builds on K–8 and progresses to using
algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric
functions, exponentials and logarithms, and computational tools for statistical analysis to analyze,
represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- **LS2-1** Use mathematical and/or computational representations to support explanations
- **LS2-2** Use mathematical representations to support and revise explanations
- **LS4-6** Create or revise a simulation of a phenomenon, designed device, process, or system.

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- **LS2-7** Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

NGSS Disciplinary Core Ideas

LS2-A Interdependent Relationships in Ecosystems

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1),(HS-LS2-2)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6)
- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HS-LS2-7)
- 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. (secondary to HS-LS2-7), (HS-LS4-6)

ETS1.B: Developing Possible Solutions

- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (secondary to HS-LS4-6)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS- LS2-3)
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)

AP BIology Science Practices:

Science Practice 2: Students can use mathematics appropriately.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?* **Crosscutting Concepts**
● Why would the removal of a keystone species have such a drastic effect on an ecosystem? ● How do the laws of conservation of matter and thermodynamics drive what happens in ecosystems? ● Does ecology determine evolutionary trends or does evolution determine ecological change?	Students will understand: **Stability and change** ● Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6), (HS-LS2-7) **Systems and System Models** ● Models (e.g., physical mathematical computer models) can be used to simulate systems and interactions -- including energy, matter and information flows -- within and between systems at different scales. (HS-LS2-5) **Energy and Matter** ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6)

	● Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.(HS-LS1-7),(HS-LS2-4) ● Energy drives the cycling of matter within and between systems. (HS-LS2-3) **Essential Knowledge 4.B.4 Distribution of local and global ecosystems changes over time.** ● Human impact accelerates changes at local and global levels. ○ Logging, agriculture, infrastructure, climate change. ○ Introduction of new or invasive species can alter organisms' realized niches. ● Geological and meteorological events impact ecosystem distribution. ○ Biogeographical studies support this ■ El nino ■ Continental drift **Essential Knowledge 4.C.3 The level of variation in a population affects population dynamics** ● Populations ability to respond to change in the environment is impacted by genetic diversity. ○ California condors (reintroduction and maps activity) ○ Prairie chickens **Essential Knowledge 4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem.** ● Natural and artificial ecosystems with fewer component parts and with little diversity among the parts are often less resilient to changes in the environment. ● Keystone species, producers, essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem.

	○ Effect of keystone species are disproportionate relative their abundance. ○ When keystone species are removed a collapse of the ecosystem is seen. **AP BIOLOGY Enduring Understanding** **2.A:** Growth, reproduction and maintenance of the organization of living systems require free energy and matter. **3.E:** Transmission of information results in changes within and between biological systems. **4.A:** Interactions within biological systems lead to complex properties.
Areas of Focus: Proficiencies (Cumulative Progress Indicators	**Lesson Possibilities**
Students will: ● Explain how the behavioral and/or physiological response of an organism is related to changes in internal or external environment. ● Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of the population. ● Describe the strategies organisms use to acquire and use energy. ● Explain how changes in energy availability affect populations and ecosystems. ● Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem. ● Describe factors that influence growth dynamics of populations. ● Explain how the density of a population affects and is determined by resource availability in the environment. ● Describe the structure of a community according to its species composition and diversity ● Explain how interactions within and among populations influence community structure	● Inquiry lab to start: (if materials are available) Pill Bug animal behavior lab. ● Notes on basics of ecology and how biotic components are dependent on abiotic components. ○ phototropisms and periodisms in plants ○ taxis and kinesis in animals ○ fight or flight ○ animal behavior ● Discussion on energy transfer and matter cycling (linking back to thermodynamics) ○ food chain and webs ○ biogeochemical cycles ○ trophic levels and energy pyramids ● Population and community ecology ○ dispersion, density, distribution ○ density dependent and independent factors and carrying capacity. (math calculations involved) ○ Bubble lab and logistic vs exponential growth. ● Biodiversity notes ○ How does biodiversity impact evolution?

• Explain how community structure is related to energy availability in the environment. • Describe the relationship between ecosystem diversity and its resilience to changes in the environment. • Explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long term structure. • Explain the interaction between the environment and random or preexisting variations in populations. • Explain how invasive species affect ecosystem dynamics. • Describe human activities that lead to changes in ecosystem structure and/ or dynamics • Explain how geological and meteorological activity leads to changes in ecosystem structure and/or dynamics. **Career-Ready Practices** **CRP1**: Act as a responsible and contributing citizen and employee. **CRP2**: Apply appropriate academic and technical skills. **CRP4**: Communicate clearly and effectively and with reason. **CRP5**: Consider the environmental, social and economic impacts of decisions. **CRP6**: Demonstrate creativity and innovation. **CRP7**: Employ valid and reliable research strategies. **CRP8**: Utilize critical thinking to make sense of problems and persevere in solving them. **CRP9**: Model integrity, ethical leadership and effective management. **CRP11**: Use technology to enhance productivity. **CRP12**: Work productively in teams while using cultural global competence.	
Differentiation	**Assessments**
Interdisciplinary Connections	**Formative Assessments:**

● Environmental Science: Biomes, human impact, biogeochemical cycles. ● Physics: Law of thermodynamics, Law of conservation of energy, Law of conservation of matter ● Chemistry: Cycling of matter. ● History: Dust bowl and impact on nutrient cycling ● Math: Population dynamics, logistical, exponential growth. **Technology Integration Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology** ● Graphing software to compare survivorship curves (google sheets). ● Mapping program from UCSD workshop **Media Literacy Integration** ● Google Maps ● Online source for current events on ecological issues. **Global Perspectives** ● Utilization of global mapping sites can help visualize changes in various ecosystems. ● Climate change and human impact touches all areas of the world.	● Various FRQ question. ● Albert AP questions ● AP Biology practice tests **Summative Assessments and projects** ● Data analysis utilizing google maps and reintroduction of species ● Carrying capacity and food supply simulation ● CER various topics ○ reintroduction projects, invasive species, climate change, HIPPO etc. ● Food web activity and mathematics of energy transfer. ○ Biogeochemical cycle POGIL ○ NCCSTS Case Studies.

Resources used:
https://apcentral.collegeboard.org/pdf/ap-biology-course-and-exam-description-0.pdf
AP Biology Course and Exam Description Fall 2020

https://apcentral.collegeboard.org/pdf/bio-appendixc-apbiologyconceptsataglance.pdf?course=ap-biology
AP Biology Concepts at a glance

https://apcentral.collegeboard.org/courses/resources/science-practices
AP Biology Science Practices

https://sciencecases.lib.buffalo.edu/
National Center for Case Study Teaching in Science